Water Power

INTERNATIONAL DEVELOPMENT OF HYDRO-ELECTRIC POWER

NOVEMBER 1951

L 627,052
W31

THE JOHN CREHAN LIBRARY
RECEIVED
NOV 9 1951

BURRINJUCK DAM NEW SOUTH WALES

Just prior to the peak of flood this photograph of the Burrinjuck Dam was taken showing the spillways running to the full. Slightly later, the Dam itself was over-topped.

The Power House is to be seen out in the stream beside the left bank spillway. Later, the water reached almost to its roof-top. Being flood proof up to roof level; fully automatic and under remote control, the Station continued working to full capacity throughout the whole period of the flood.

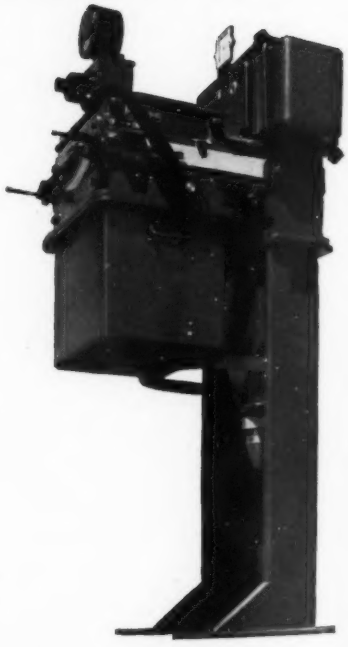
This photograph is by courtesy of "The Sun," Sydney, and was taken through the mist from a height of some thousands of feet.

Boving
& COMPANY LIMITED WATER POWER ENGINEERS

LONDON : AUSTRALIA : NEW ZEALAND : INDIA : PAKISTAN

We never lose interest in our own

We feel almost maternal about our switchgear and we're prepared to go to great lengths to keep it working sweetly. Not that we're called out every day. Our switchgear—and our customers' maintenance—is too good for that. But should a customer require additional service and call us out, we're there before you can say : Reyrolle for reliability.



REYROLLE

A. REYROLLE & CO. LTD., HEBBURN, CO. DURHAM.

SWITCHGEAR

CRC.13 S.

'ENGLISH ELECTRIC'

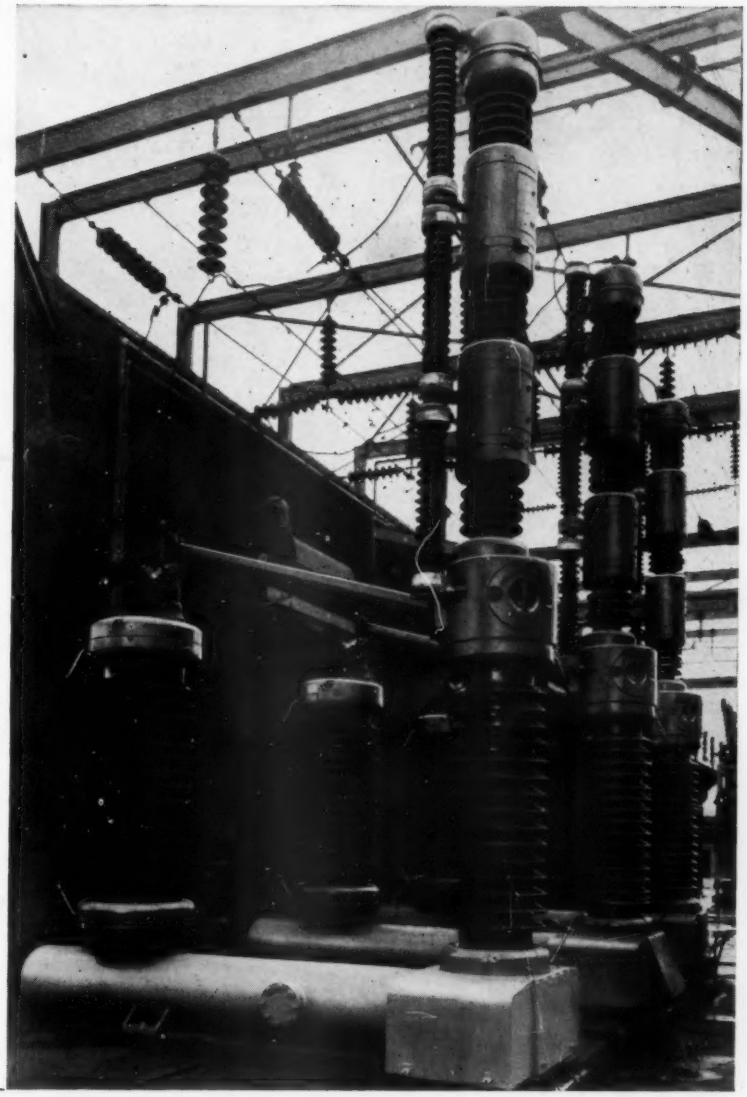
switchgear

High voltage air-blast circuit-breakers for outdoor service

Tested for breaking charging currents of long lines

•

Illustrated is a 165-kV, 3,500-MVA air-blast circuit-breaker recently tested for breaking line charging currents at Fontenay, France.



The ENGLISH ELECTRIC Company Limited

QUEENS HOUSE, KINGSWAY, LONDON, W.C.2.

Switchgear Department, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL

SH.1.

Ultimate Development of over 2,000,000 H.P. in one Canadian Plant

Dominion Engineering

Hydraulic Turbines

The sectionalized Francis runners used at Beauharnois are among the largest ever made.

The Quebec Hydro Electric Commission controlled power installation at Beauharnois near Montreal, at the down stream end of the 15 mile long, three quarter mile wide canal between Lake St. Francis and Lake St. Louis.

38 units developing 55,000 H.P. each, with a head of 80 ft., represent the ultimate installation at present planned for Beauharnois.

14 Dominion Engineering Francis Hydraulic Turbines of the vertical shaft type are now in operation. Three *more* Dominion Turbines have already been ordered for an extension, now under construction, which will accommodate 12 units when completed.

As manufacturers of Hydraulic Turbines—Francis, Propeller and Impulse types—for over 30 years, we invite your inquiries. Write for Dominion Hydraulic Turbines Bulletin No. 201.

DOMINION ENGINEERING
COMPANY LIMITED
MONTREAL, CANADA D CABLE: DOMWORKS

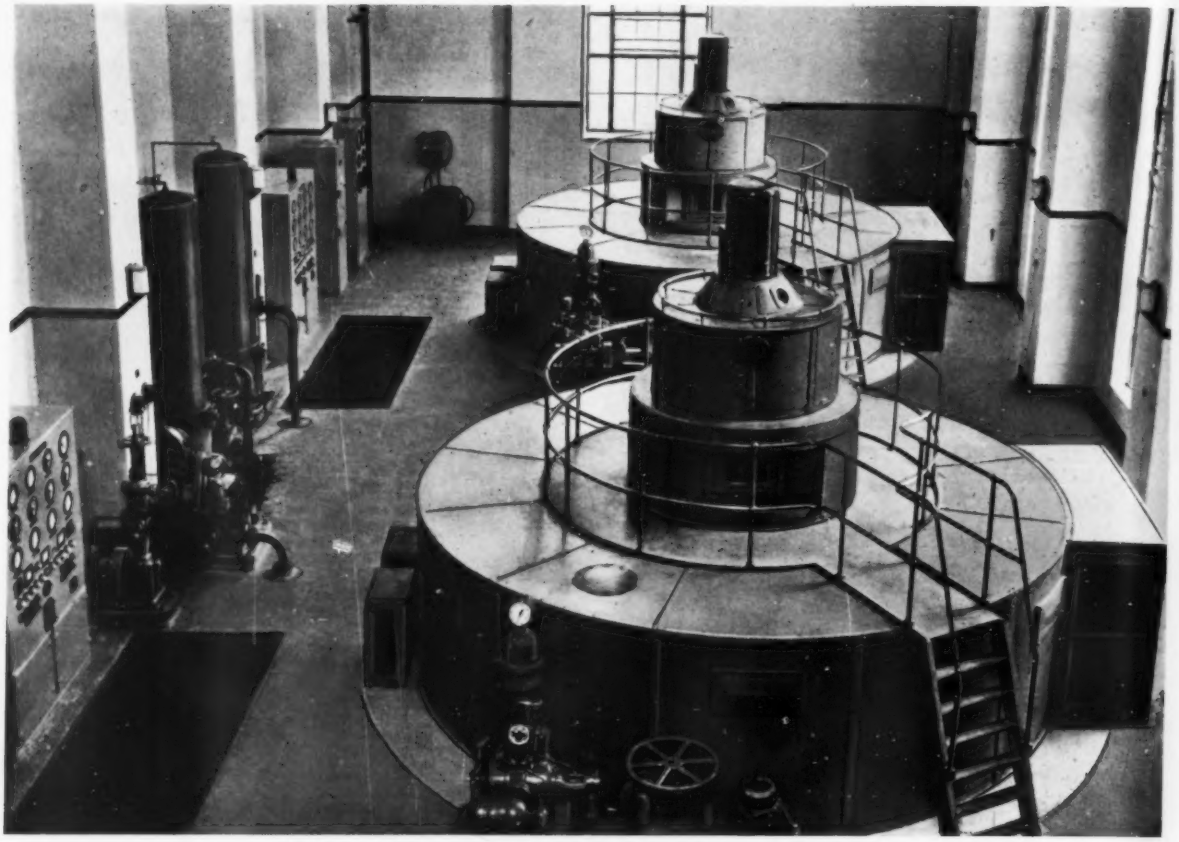
Reliable operation with
BROWN BOVERI
machines and apparatus

For power stations of all kinds (water, steam and Diesel power stations) we supply generators, transformers, complete switchgear and control rooms, regulating and protecting equipment, remote supervisory control equipment, and carrier telephone links. In addition, for steam power stations, we build Velox boilers, steam turbine sets, and condensing plants.

Machine hall of the Samina high-head hydro-electric station of the Liechtensteinische Kraftwerke, Vaduz, showing two alternators rated 4,000 kVA at 1,000 r.p.m., 10,500 V, 50 c/s, each.

The entire switching station equipment, comprising air-blast circuit-breakers and oil-less current and voltage transformers was also supplied by Brown Boveri.

BROWN, BOVERI & CO., LTD., BADEN (SWITZERLAND)

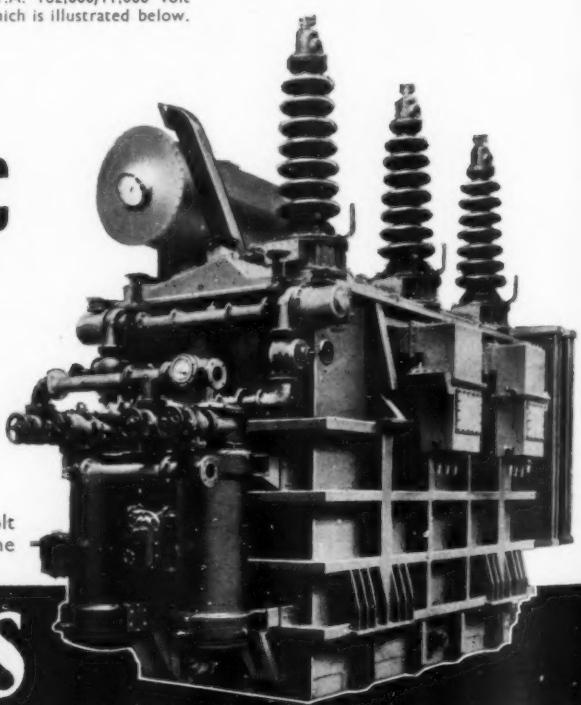


LOCH FANNICH PROJECT, North of Scotland Hydro-Electric Board. View of Grudie Bridge power station showing two 12,000 K.W. 11,000 volt, 500 r.p.m. vertical generators. The installation includes two 20,000 K.V.A. 132,000/11,000 volt water-cooled transformers, one of which is illustrated below.

PEEBLES

hydro-electric plant

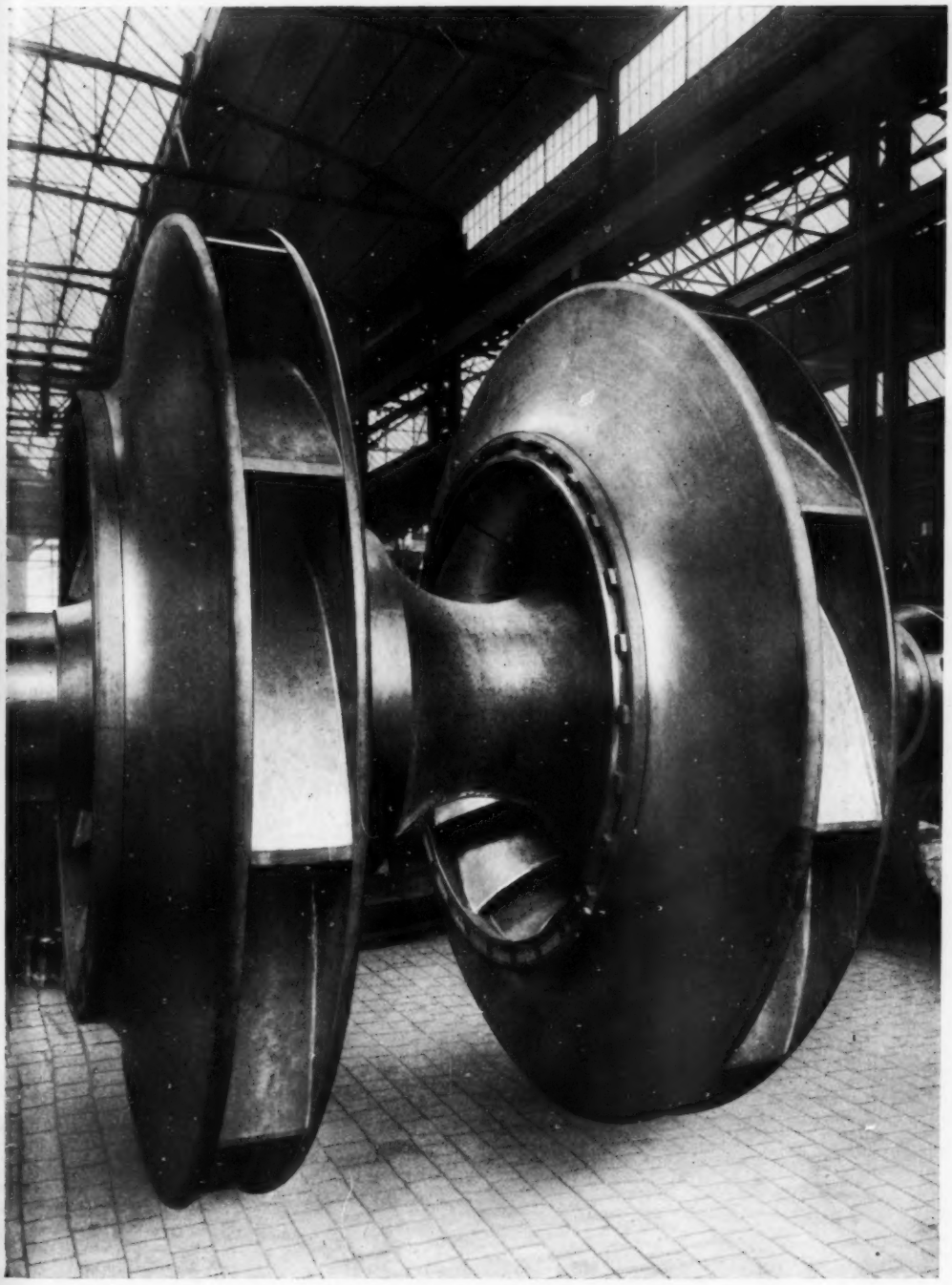
Bruce Peebles build large and small generators for all types of water turbines, and transformers up to the largest sizes for hydro-electric power distribution.



20,000 kVA. 132,000/11,000 volt water-cooled transformer for the Loch Fannich scheme.

BRUCE PEEBLES

Advertisement of BRUCE PEEBLES & CO. LTD. · ENGINEERS · EDINBURGH · SCOTLAND



ESCHER WYSS ZURICH

One of four two-stage storage pumps recently supplied by Escher Wyss, each discharging against a manometric head of 248-272 metres with a power input of 39100 to 34600 H.P. We have supplied such storage pumps with up to 60100 H.P. input per unit for discharging 14200 lit/sec. against a manometric delivery head of 270 metres.

Escher Wyss further specialize in Kaplan, Francis and Impulse turbines up to the largest outputs and heads, as also in other hydraulic equipment.

Our experience in manufacture and in installation work all over the world is at your disposal.

ESCHER WYSS LTD., ZURICH (SWITZERLAND)

The fastest, most economical method of placing BULK CONCRETE giving

Blaw Knox concrete pipe lines on the construction of the Royal Festival Hall—Main Contractors—Messrs. Holland & Hannen and Cubitts Ltd.

BETTER
placing of high quality concrete at the lowest cost per cubic yard.

BETTER
placing on awkward sites—uphill, downhill and underwater . . . traversing highways and railway tunnels without obstructing traffic.

BETTER
placing without rehandling problems . . . no chutes, hoists, towers, buckets, cranes, etc.

BETTER
utilisation of man-power—with one man more concrete can be placed than by a whole team using old fashioned methods.

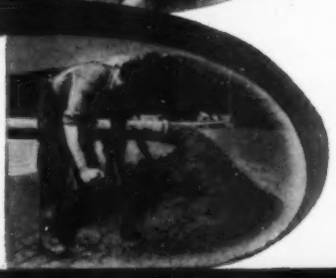
PUMP IT

Basic component of the system is the BLAW KNOX portable, two speed, heavy duty, single acting horizontal piston pump. Capacity 15-20 cubic yards of concrete per hour.

PIPE IT

BLAW KNOX Concrete Pipelines comprise 6″ steel pipes in various lengths up to 10′ and simple, quick-acting couplings with rubber seatings for fast assembly and dismantling. During pumping the pipeline is completely filled, concrete moving through in synchronous impulses in an excellent state of uniformity.

PLACE IT



Concrete is poured straight into the forms, exactly where it is needed.

REMEMBER GENEROUSLY SAT · NOV 10

Blaw Knox engineers will be glad to advise on the application of the Concrete Pump to specific jobs.

BLAW KNOX

BK.63

BLAW KNOX *Concrete by Pipeline*

BLAW KNOX LIMITED, 90/94 BROMPTON ROAD, LONDON, S.W.3
Telephone: Kensington 5151 Telegrams: Blawnox, Southkens, London

One of the 4 TRANSFORMERS

"Shell-Type"

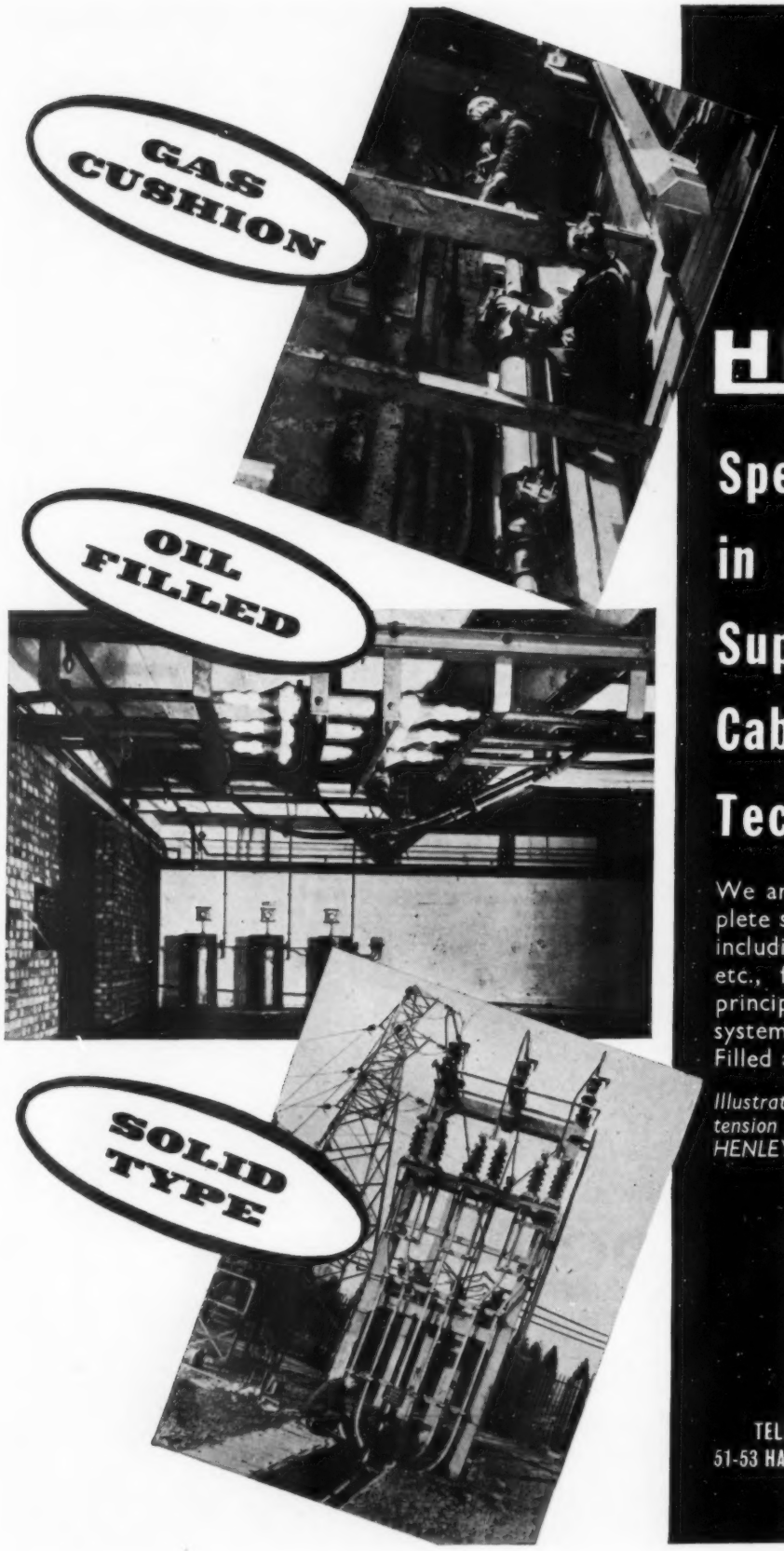
OF 75 000 kVA, INTENDED FOR THE BELGIAN CENTERS OF INTERCONNECTION FOR NETWORKS OF 150/70 kV.

75 000 kVA

3 WINDINGS : 150/70/10 kV.
ON LOAD VOLTAGE REGULATION : ± 17,5 % ON THE 150 kV SIDE
3 RANGES OF LOAD : 45 000 kVA - 60 000 kVA - 75 000 kVA according to the type of cooling system.

Ateliers de Constructions Electriques de Charleroi

CHARLEROI



HENLEY

Specialists in Super-Tension Cable Technique

We are able to install complete super-tension schemes, including joints, terminations, etc., for all three of the principal underground cable systems: Gas Cushion, Oil Filled and Solid Type.

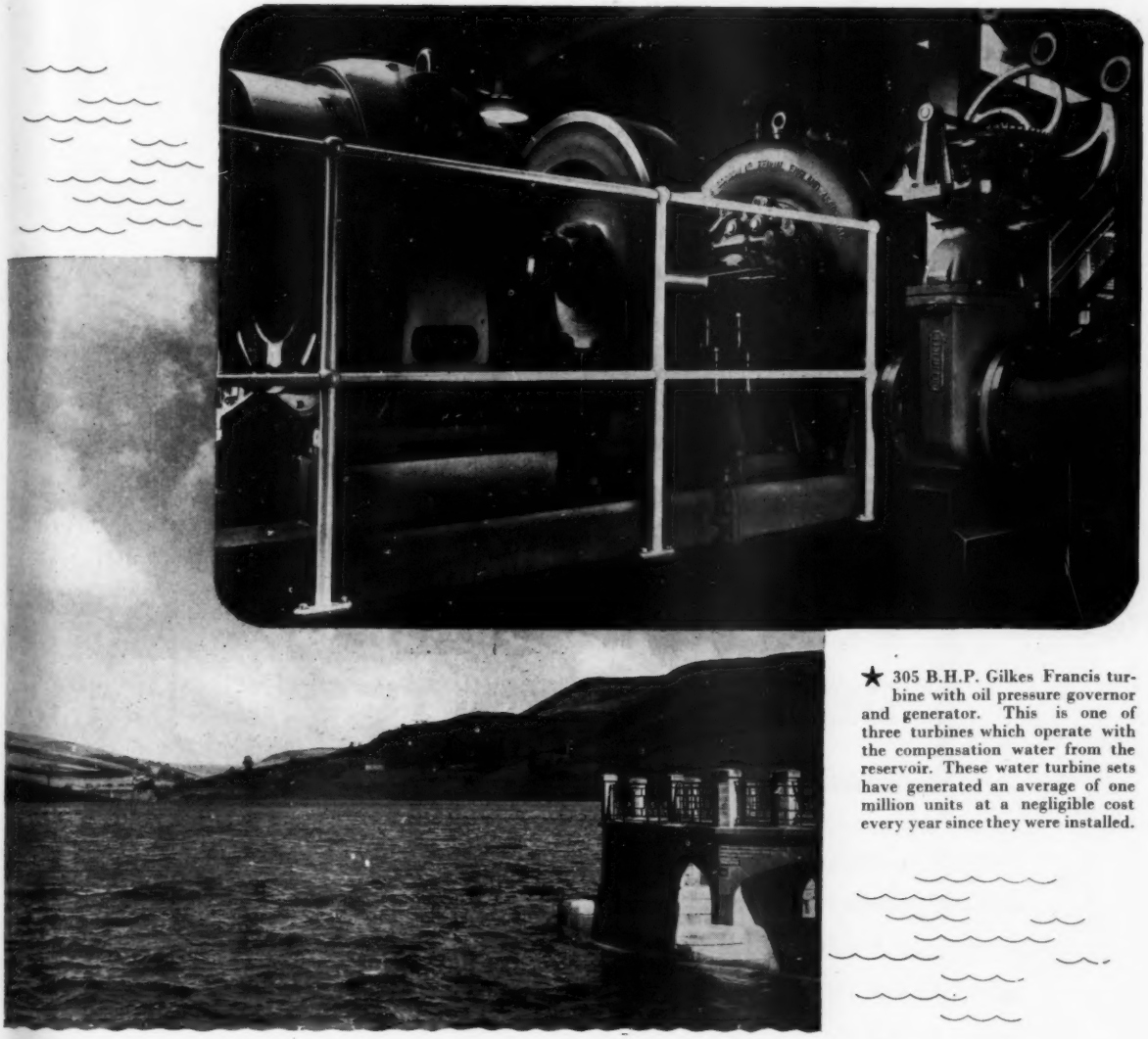
Illustrations show typical super-tension contracts carried out by HENLEY'S.

BY APPOINTMENT
ELECTRIC CABLE
MANUFACTURERS

W. T. HENLEY'S
TELEGRAPH WORKS CO. LTD.
51-53 HATTON GARDEN, LONDON, E.C.1

GILKES WATER TURBINES

at the Ladybower Reservoir, Ashopton, Derbyshire



★ 305 B.H.P. Gilkes Francis turbine with oil pressure governor and generator. This is one of three turbines which operate with the compensation water from the reservoir. These water turbine sets have generated an average of one million units at a negligible cost every year since they were installed.

At the Ladybower Reservoir, one of the largest stretches of artificial water, the Derwent Valley Water Board has installed three Gilkes Water Turbines totalling 660 B.H.P.

GILBERT GILKES & GORDON LTD.

KENDAL 'Phone: Kendal 28 ENGLAND

WATER TURBINE AND PUMP MANUFACTURERS

London Office: CRAVEN HOUSE, KINGSWAY, LONDON W.C.2 *'Phone: Holborn 3232*

G. 29

FOR MORE POWERFUL PRODUCTION TOOLS

C.P.124

REMEMBER GENEROUSLY SAT · NOV 10

Reliability, sound design, good workmanship — these are taken for granted in any tools which bear the CP monogram. But it is in their vast reserves of power that CP tools are way ahead . . . power which gets the job done more quickly . . . power which avoids bottlenecks . . . power which ensures that every machine is working well within its capacity. Whether your requirement is for tools using the pneumatic, Hicycle or universal electric system . . . or for compressors, stationary or portable, you cannot do better than . . .

CALL IN CONSOLIDATED

CONSOLIDATED PNEUMATIC TOOL CO. LTD. - LONDON & FRASERBURGH

Offices at Glasgow · Newcastle · Manchester · Birmingham · Leeds · Bridgend · Belfast · Dublin · Johannesburg
Bombay · Melbourne · Paris · Rotterdam · Brussels · Milan · and principal cities throughout the world

Dam Building

and similar work . . . . .

A BUTTERS CRANE

designed for the purpose

Specially devised for erection in difficult situat'ons the Butters Monotower Crane combines

Great height of lift
Large radius
Full circle coverage
on a
very small erection area

The photograph shows a typical example; this is an electric crane with a maximum capacity of 5 tons and a maximum radius of 100 feet, operating through a full circle

We shall be pleased to send particulars of our Monotower Cranes or of any other type on request

Butters Bros. & CO. LTD. ENGINEERS & CRANE BUILDERS

Head Office :
MACLELLAN STREET, GLASGOW, S.1

Telephone
IBROX 1141 (6 lines)

Telegrams and Cables
BUTTERS, GLASGOW

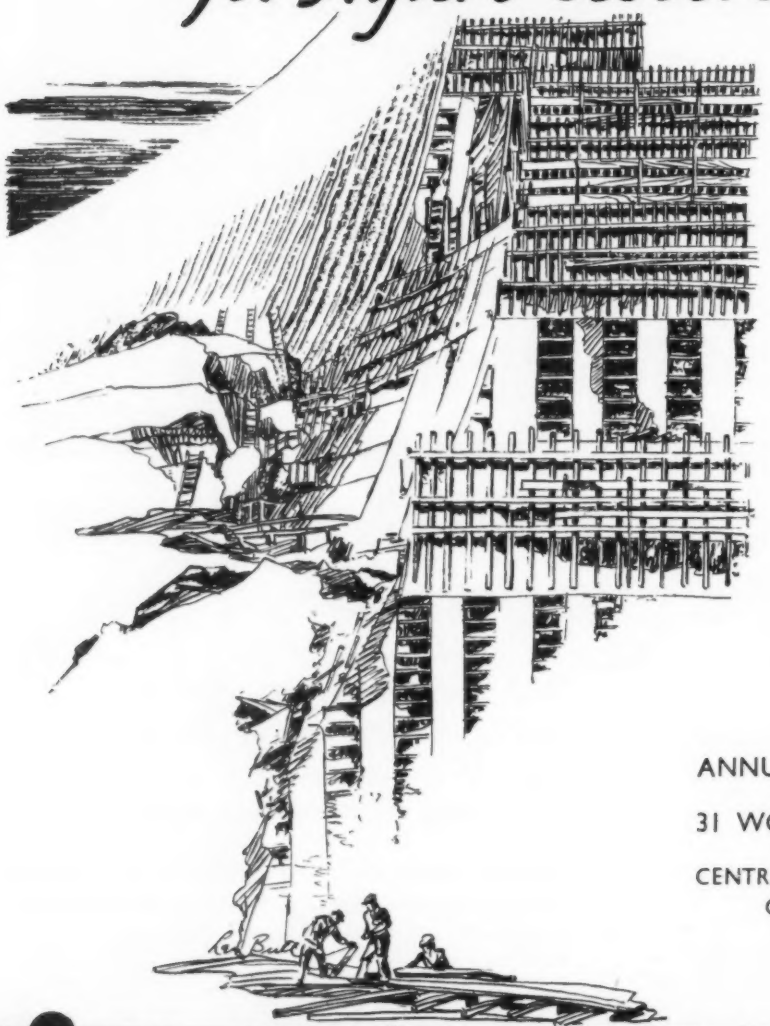
London Office & Works :
The Crane Works, Long Lane,
Hillingdon, Middx.

Birmingham Office :
County Chambers, Corporation Street.
Telephone : Central 6043

Newcastle Office :
65 Quayside. *Telephone :* 21067

Cement

for Hydro-electric schemes



Exporters to all parts of the World

Cement complying with BSS No. 12/1947

Special low heat cement for dams

White Cement. High early strength cement

Special pozzuolanic cement for sea works

•

ANNUAL CAPACITY 3,000,000 TONS

31 WORKS THROUGHOUT ITALY

CENTRAL LABORATORY FOR RESEARCH ON CEMENT & CONCRETE

ITALCEMENTI

CAPITAL—ITALIAN LIRE 4,000,000,000

FABBRICHE RIUNITE CEMENTO

BERGAMO · ITALY

ADDRESS: "ITALCEMENTI," P.O.B. 247, BERGAMO (ITALY) · CABLES: ITALCEMENTI, BERGAMO

Well that's the tenth hole this shift! Fair treat, this MAXLEG — does all the pushing and shoving for you. Smacks them in straight as a die. Up in the roof, down on the ground — doesn't make any difference. Proper picnic compared to the old days.

Please send for our illustrated leaflet No. 102, which gives full details of the Maxleg.

CLIMAX

CLIMAX ROCK DRILL & ENGINEERING WORKS LTD.

4, Broad Street Place, London, E.C.2. Works: Carn Brea, Redruth, Cornwall

TAS/CX 500

The safe link

We specialise in manufacturing Power Transformers for Generation. Transmission and Distribution. All YORKSHIRE Transformers are designed, constructed and tested to the corresponding British Standard Specification.

We make Transformers to suit all requirements up to 45,000 k.V.A. - 132,000 volts.

YORKSHIRE TRANSFORMER

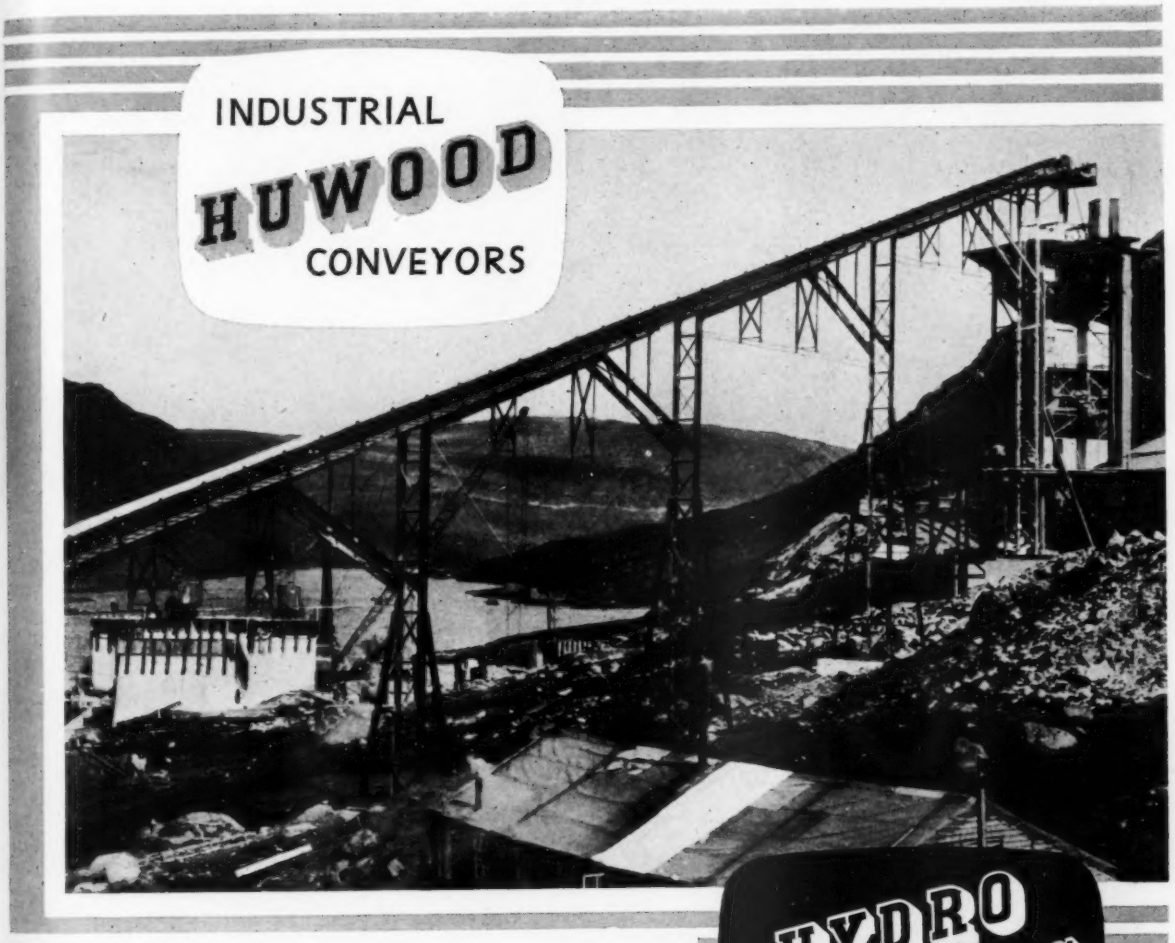
YET

Phone. DEWSBURY 1691/2

YORKSHIRE ELECTRIC TRANSFORMER Co LTD DEWSBURY · ENGLAND

Quarry to Batching PLANT

STONE & AGGREGATE



HYDRO ELECTRIC

SCOTLAND · TUMMEL GARRY · LOCH SLOY
ERROCHTY DAM

AFRICA · OWEN FALLS · UGANDA

INDIA · HIRAKUD DAM PROJECT

HUGH WOOD & CO. LTD.

HUWOOD

Head Office & Factories : GATESHEAD-ON-TYNE, 11

Industrial & Export Office : DASHWOOD HOUSE, 69, OLD BROAD STREET, LONDON, E.C.2

IND/120C/1

Essential to the construction of the big jobs
Henderson
AERIAL CABLEWAYS
for Hydro-Electric Schemes
Night and day in all weathers Henderson Aerial Cableways consistently maintain scheduled construction programmes. The speed, economy and efficiency of Henderson Cableways are essential factors in large building, constructional and hydro-electric undertakings. Henderson Cableways were used for the construction of the Dams at Loch Sloy and Glen Shira, North Scotland, Hydro-Electric Board, and various other home and overseas undertakings.

JOHN M. HENDERSON AND COMPANY LIMITED · KING'S WORKS . ABERDEEN Phone 24262

HYDRAULIC TURBINES

Vevey

Lavey Hydro-electric Power Plant
33'650 HP Kaplan Turbine

Ateliers de Constructions Mécaniques de Vevey S.A.

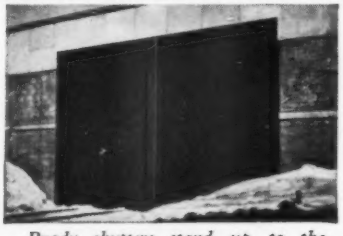
Vevey / Switzerland

Complete Equipment for Hydro-electric Power Plants

1424

LIKE BRITAIN . . .

Canada chooses BRADY PATENTED



Brady shutters stand up to the most arduous climatic conditions—this is a Brady installation for Shipping Containers Ltd., in Montreal.

Efficient routine service, no less than enterprise, makes 'Brady' a by-word in Canada too. This gear-operated bank of four steel shutters was recently fitted for the Dominion Textile Company Ltd., of Montreal. A standard roller-shutter installation, it is just one example of everyday service by Brady abroad. There as in Britain, our organisation sets itself out to meet the normal and unusual roller-shutter specifications with equal efficiency.

We shutter the world

BRADY PATENTED

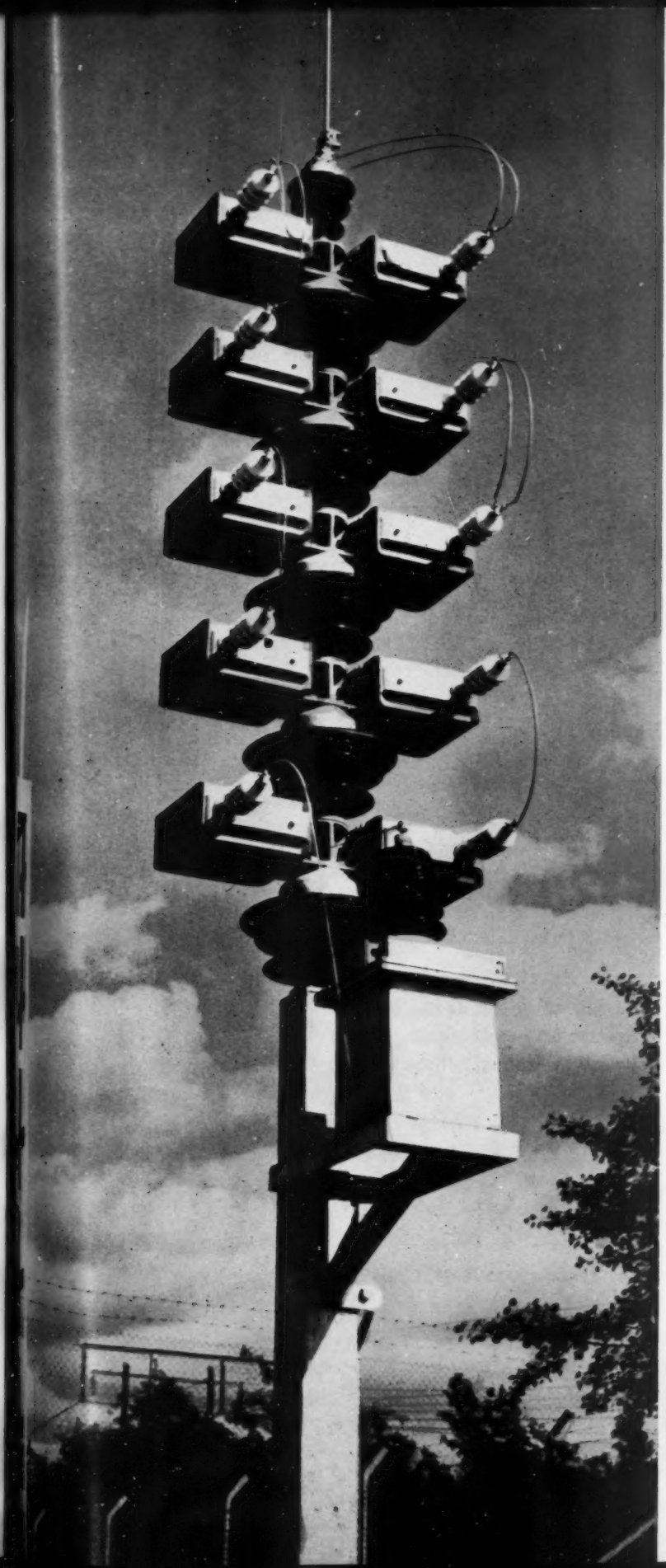
G. BRADY & CO. LTD · ANCOATS · MANCHESTER 4 · Phone: COLlyhurst 2797/8

LONDON: New Islington Works, Park Royal, N.W.10 *BIRMINGHAM: Rectory Park Road, Sheldon 26*

CANADA: c/o DAVID C. ORROCK & CO. 1405 Bishop Street, MONTREAL 25.

Manufacturers of Brady Hand and Power Operated Lifts

Steve & Bowden



Capacitor Type Voltage Transformers

The capacitor is built up of standard units carried on a column composed of ordinary supporting porcelain insulators. Welded steel containers with soldered bushing terminals obviate any risk of oil leakage due to imperfect seals.

*

Capacitors for different line voltages are composed of suitable numbers of identical standard units. This method of unit construction makes the transformers readily convertible to any desired voltage rating and greatly simplifies the spares problem.

*

The accuracy of measurement is practically unaffected by snow or dirt on the insulator porcelain, owing to the large capacitance. Each transformer is equipped with two secondary windings and an adjustable auxiliary winding corresponding to the capacitor tolerance. The burden on one winding when the other is unloaded is 150 VA class 0.6 and 200 VA class 1.2 according to ASA and 200 VA class B according to BSS specifications. Normal frequency fluctuations will not appreciably affect the accuracy of measurement. The other secondary winding—for relays—is reconnectible for 110, $110/\sqrt{3}$ and 110/3 V.

*

The illustration shows a 220 kV capacitor type voltage transformer mounted on a column of the type used by the Swedish State Power Board.

ASEA

Västerås - Sweden

CHRISTIANI & NIELSEN

CIVIL ENGINEERS AND CONTRACTORS—ESTABLISHED 1904

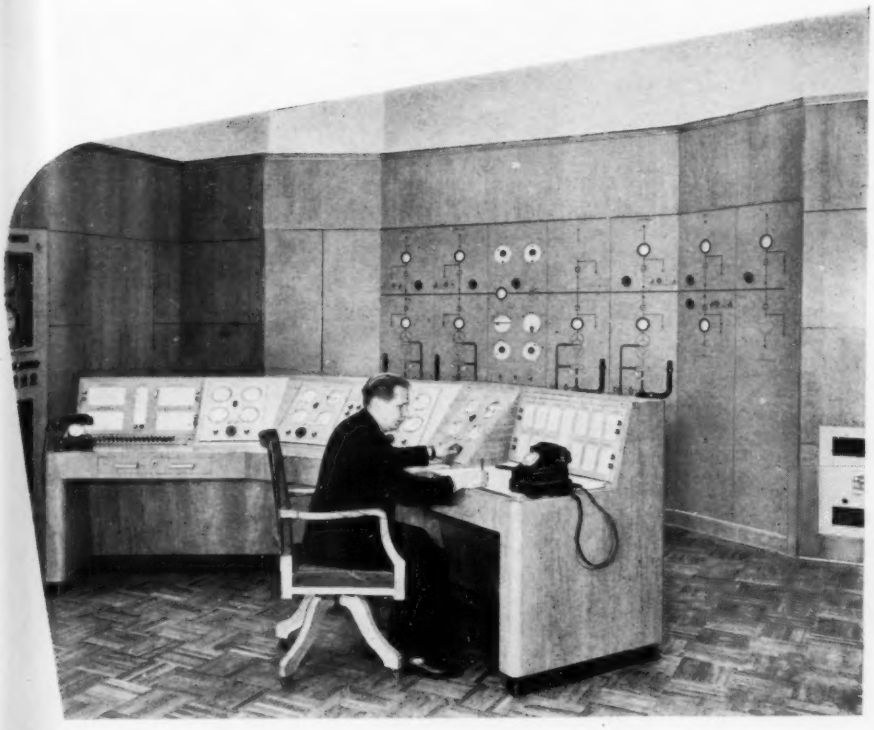
Backed by the experience gained during 47 years working in 35 countries, the Christiani & Nielsen Organisation can undertake large-scale civil engineering work of all types in any part of the world.

SPECIALITY: Marine and Hydraulic Structures.

LONDON OFFICE: 54 Victoria Street, S.W.1.
Telegrams: Reconcret, London.

CENTRAL DESIGNING OFFICE: Vester Farimagsgade 41, Copenhagen
Telegrams: Jernbeton, Copenhagen

ALSO OFFICES IN: Aarhus - Asuncion - Bahia - Bangkok - Bogota - Buenos Aires - Cape Town Caracas - Durban - Guayaquil - Hamburg - Helsingfors - Lima - Lourenco Marques - Mexico City Montevideo - New York - Oslo - Paris - Rangoon - Rio de Janeiro - Sao Paulo - Stockholm - The Hague.



128 MW at 132 kV under fingertip control

STANDARD Generator Control desk and mimic diagram at Loch Sloy power station provides full facilities for direct indication and control of four 32 MW generators and six 132 kV feeders. Generator controls include Raise-Lower speed, Raise-Lower excitation and Open-Close generator circuit breaker. Fingertip controls operate 50V D.C. circuits at a few milliamps, enabling telephone cable to be used instead of the multi-core V.I.R. cable needed with older systems. All protective devices are continuously monitored and indicated by a STANDARD Direct Wire Alarm system.

LEADERS for 30 years in the field of remote control of switchgear, *Standard* have installed systems throughout the world. Now, at Loch Sloy, *Standard* again lead with the first Miniature Direct Wire Remote control system to be applied to the control of hydro-electric generators.

At LOCH SLOY, the most modern hydro-electric power station in the world, all turbine, generator, switchgear controls and meters necessary for synchronising and efficient loading have been centralised in the control room by means of *Standard* Miniature Direct Wire Remote Control.

Using entirely telephone-type apparatus, this advanced control system convincingly demonstrates that miniature, easy-to-handle equipment is safe and reliable when applied to the control of the largest generators and is indicative of *Standard's* ability to meet, in the field of telecommunications, the most exacting requirements of modern power generation.

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

TELEPHONE DIVISION · Oakleigh Road, New Southgate, London, N.11

MARIONS for BIG Yardage

Robust construction, electric swing and fast easy-to-operate air controls, mean full-time operation by both excavator and operator.

EARLY DELIVERY OF 3½/4 CU. YD. MODEL 111—M

MARION EXCAVATORS in all sizes from ¾ to 45 cu. yds.

With a complete After Sales Service by the sole distributors.

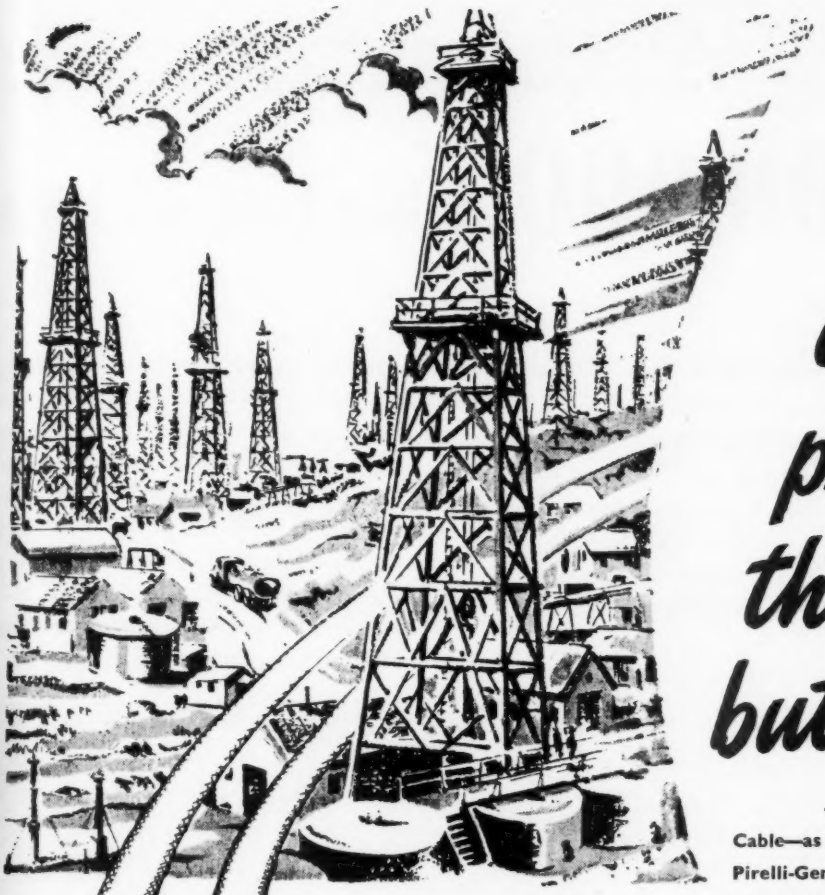
BLACKWOOD HODGE

Sales:
11 BERKELEY ST., W.1.
Telephone: Mayfair 9090

POWER SHOVEL COMPANY MARION SINCE 1884

Works and Service:
HUNSBURY, NORTHAMPTON
Telephone: Northampton 5262

U.K., U.S.A., EIRE, BELGIUM, FRANCE, PORTUGAL, SPAIN, ITALY, S. AFRICA, E. AFRICA, W. AFRICA, RHODESIAS & NYASALAND, BELGIAN CONGO, ANGOLA, MOZAMBIQUE, SUDAN, INDIA, PAKISTAN, CEYLON, BURMA, AUSTRALIA



we don't produce the oil but

—in the production of Oil-Filled Cable—as indeed of all types of cable—the Pirelli-General Cable Works is a *complete* manufacturing unit. As with other raw material used, so with Oil. On delivery it passes immediately into the control of men whose job it is to condition it for one highly specialised purpose—that of cable manufacture. P-G chemists and technicians test the Oil for dielectric strength, power factor and electrical stability. They clarify and degasify it until as processed oil it is again tested before being pumped into pressurized reservoirs for ultimate use in oil-filled cables, joints and accessories—all top-grade products worthy of the name **PIRELLI-GENERAL.**

P G

33 kV to 330 kV

OIL-FILLED SUPER TENSION CABLE

PIRELLI-GENERAL

MANUFACTURERS OF EVERY KIND OF ELECTRIC CABLE

PIRELLI-GENERAL CABLE WORKS LTD., SOUTHAMPTON. *(An Associate of The General Electric Co., Ltd.)*

● *In these days, when so much emphasis is being placed on greater productivity through improved methods, this story is particularly apt.*

10,000,000 cubic feet of leptite...

TODAY the waters of the River Faxälven, passing from the turbines of the Hjälta Power Station* return to their original course through a gigantic discharge tunnel pierced through nearly 3¾ miles of rock. The three great turbo-generators at this plant are housed in a hall blasted out of solid rock at a depth of 240 feet below ground level. The water is carried down to the turbines by steel pipelines and back to the river by the great tunnel described here.

This tunnel, which represented the major part of the work, presented many problems. Its dimensions alone were formidable: 40 ft. 2 ins. wide by 39 ft. 8 ins. high, with a rock face area of 1,450 square feet and a length of 20,116 feet, or 3 miles, 6 furlongs, 105 yards. Moreover, the rock was difficult, consisting for the most part of leptite, and there were 10,000,000 cubic feet to be drilled and blasted! This was the task chosen to test the Swedish method—the new rock-drilling system based on the use of light one-man Atlas Drills and Sandvik Coromant hard metal Drill Steels.

After a preliminary drilling and blasting test it was decided to work to a planned rate of advance of 18 feet per round, and 15 men, operating 17 rock drills, were installed at the rock face. At each round 121 holes were drilled and the aggregate depth drilled per round was no less than 2,227 feet! At each blasting 22,557 cubic feet of rock was dislodged.

Neither long stretches where the rock was badly fissured, nor a band of quartz 500 feet deep which was encountered at one point, succeeded in slowing down the planned rate of advance. The result was a complete triumph for the Swedish Method. The test showed that everything which can be done with the heavier types of rock drill can also be tackled with light one-man Atlas Drills, when these are used in conjunction with Sandvik Coromant hard metal Drill Steels. But it also proved conclusively that the Swedish Method means an increase of 50% in the effective boring rate, and consequently a big reduction in boring cost per foot. Comparative estimates showed that **the Swedish Method reduced the cost of the Hjälta Power Station by one million Swedish Crowns, or approximately £68,000!**

Work in progress on the great discharge tunnel at the Hjälta Power Station. The single constructed staging on which the drillers worked at the rock face allows for the passage through it of excavators and mine cars. This staging was withdrawn a short distance on rails as each charge was exploded. From the small figures in the centre of the picture some idea of the size of the tunnel can be obtained.

* Hjälta Power Station, completed in 1949, is the second largest in Sweden, with an annual production of 960 million kWh. ARCHITECT, Professor Sven Ivar Lind; CONSULTING ENGINEERS, A/B Vattenbyggnadsbyrån; CONTRACTORS, A/B Hjälta.

...what a test for the Swedish Method!

.... How this new rock-drilling system demonstrated its superiority at the Hjälta Hydro-electric Station in Sweden and cut costs by a sum estimated at over £68,000

The actual speed of the drilling operation is not everything; it is the gross rate of advance through the tunnel which, in the final analysis, determines the value of the drilling method. And it is in this respect that the Swedish Method can show decisive advantages.

Where Atlas gets its speed

One of the main features of the Atlas Drill is its negligible weight: one man can handle it all day without fatigue. Getting the machine into any required position at the rock face takes only a matter of minutes, and it is moved forward during the course of boring in an instant. This means that some of the heaviest work often associated with tunnel boring is avoided. Power costs are appreciably lower, since the Atlas machine requires only 20 h.p. as compared with 40 h.p. for the heavier drifter-type machines. But its greatest advantage lies in its easy manœuvreability. An Atlas Drill is actually drilling for 85% of its total time on the job, and in practice this means more feet bored at the end of each shift.

It is obvious that to obtain these results it is necessary to use drill steels capable of boring great depths in the worst kind of rock without appreciable loss of gauge. In the severe test provided by the Hjälta tunnel, Sandvik Coromant hard metal Drill Steels, made by the Sandviken Steel Works, were standard equipment with all Atlas Drills, and the combination of these two, coupled with the new drilling principles involved, have come to be known as the Swedish Method.

The toughness of the Sandvik Coromant bit is phenomenal. Loss of gauge is negligible; only about a hundredth part of that of ordinary steels. This makes it possible to drill holes with practically parallel sides and stoppages for change of drill steels are almost entirely avoided.

50 feet without re-grinding!

In the hard leptite at Hjälta, for example, Sandvik Coromant Drill Steels penetrated 50 feet without re-grinding. In such circumstances an ordinary drill steel would have to be removed for sharpening after something like 20 inches. This comparison speaks volumes for the amazing durability of Sandvik Coromant hard metal.

When it does become necessary to re-grind a Coromant bit, it can be done on the spot by any operative in a matter of minutes; the need for re-forging and the transport of drills to and from the job no longer arises.

Since the completion of the Hjälta tunnel the Swedish Method has been widely applied in mines, tunnels and quarries in many countries. All over the world it is today proving its superiority in terms of increased rate of advance, lighter work and lower drilling costs.

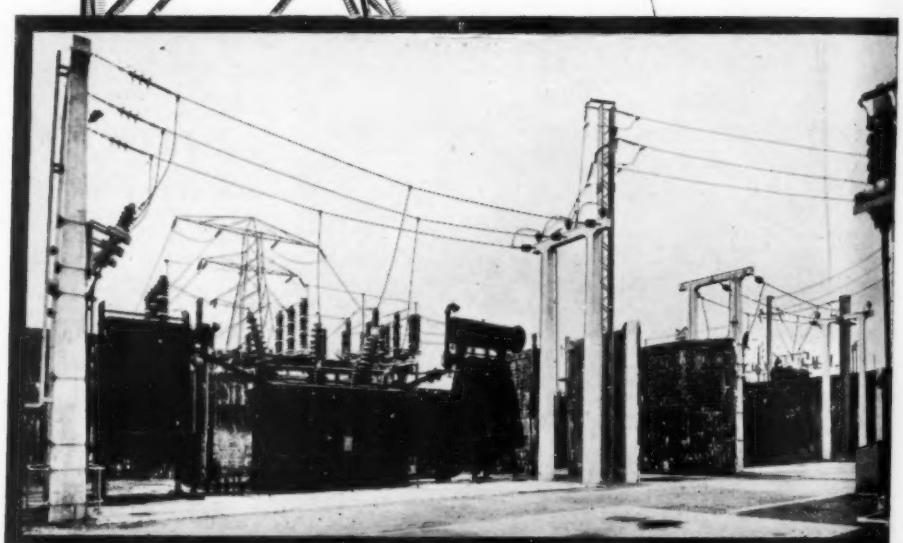
THE FULL STORY of the Hjälta tunnel, with photographs and diagrams, is told by Ragnar Ahlström, Chief Engineer to the Contractors, in ATLAS COMPRESSED AIR REVIEW, No. 2, 1950. To obtain a free copy please use the voucher on right, attaching it to your business or professional letter-heading.

VOUCHER To ATLAS DIESEL COMPANY LTD · Beresford Avenue, Wembley · Middlesex. *Please send us a copy of* **Atlas Compressed Air Review,** *No. 2, addressing it personally to:*

.....

Our business (or professional) letter-heading is attached

TRANSMISSION AND



TRANSFORMERS by G.E.C.

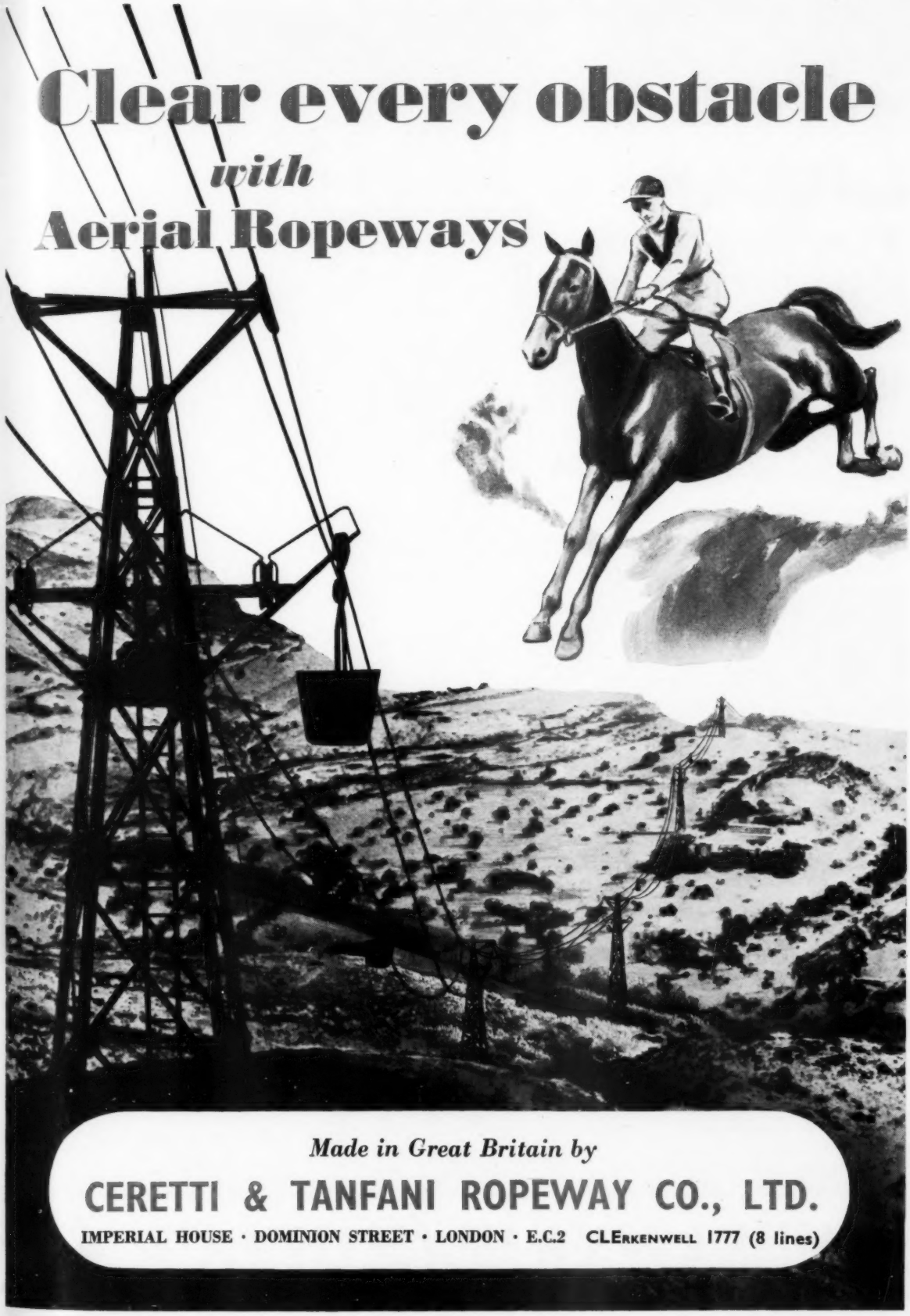
GENERATION · CONTROL · RECTIFICATION · DISTRIBUTION

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

Clear every obstacle

with

Aerial Ropeways



Made in Great Britain by

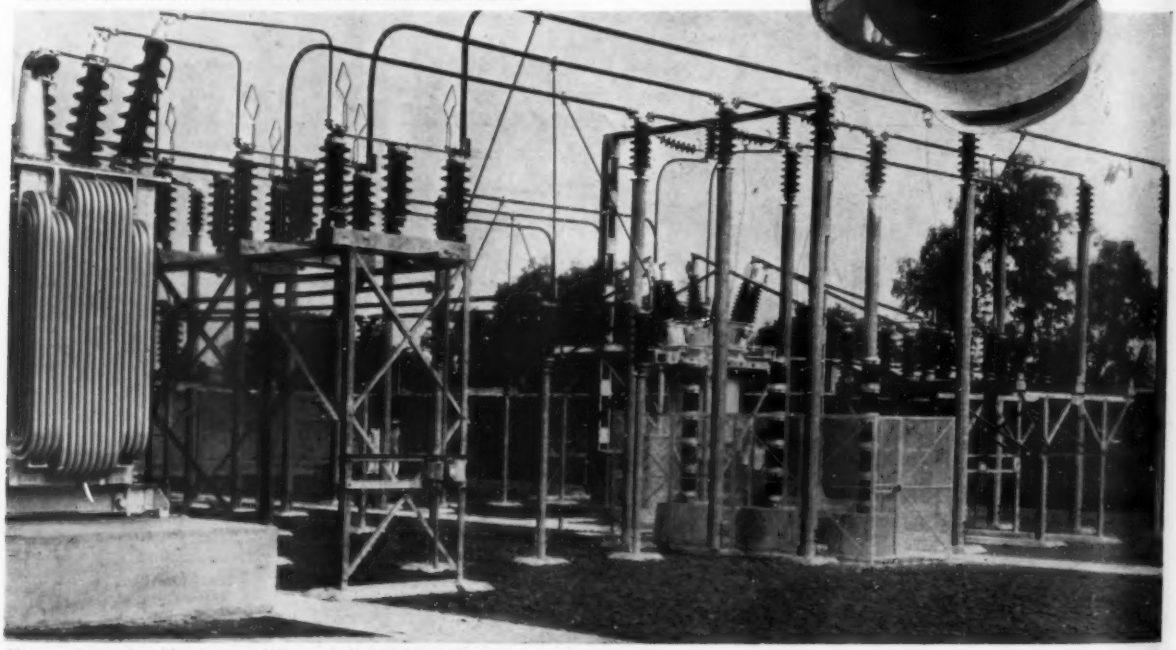
CERETTI & TANFANI ROPEWAY CO., LTD.

IMPERIAL HOUSE · DOMINION STREET · LONDON · E.C.2 CLERKENWELL 1777 (8 lines)

S.P.P. POST INSULATORS

were specified for the 66kv outdoor switchgear on the Malakand Hydro Electric Scheme

All S.P.P. Cylindrical Post Insulators are protected by British Letters Patent.



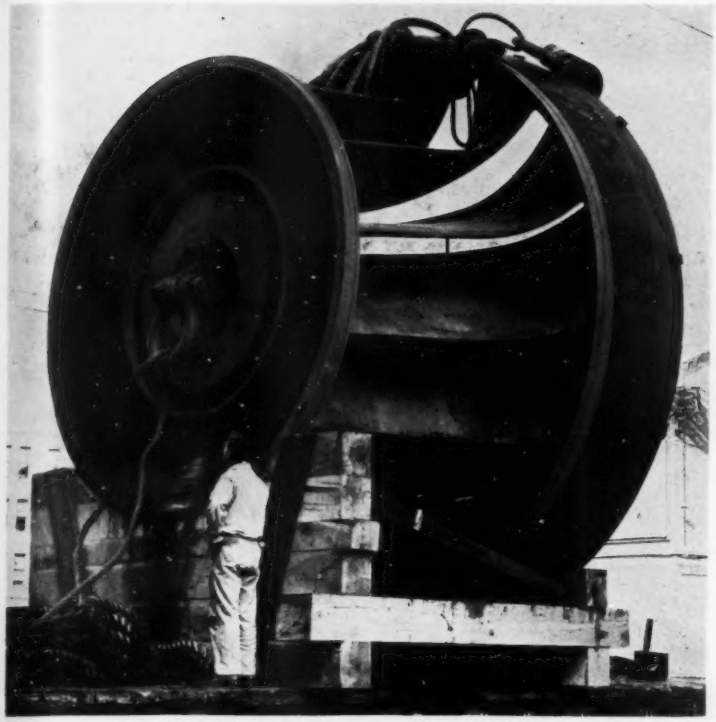
Photograph reproduced by courtesy of Messrs. A. E. I. (Pakistan) Ltd.

One of the 66kv Substations on the Malakand Scheme in the North West Frontier Province, Pakistan, equipped with S.P.P. cylindrical post insulators type P.696.

STEATITE & PORCELAIN PRODUCTS LTD.

Stourport-on-Severn, Worcestershire Telephone : Stourport 111 Telegrams : Steatain, Stourport

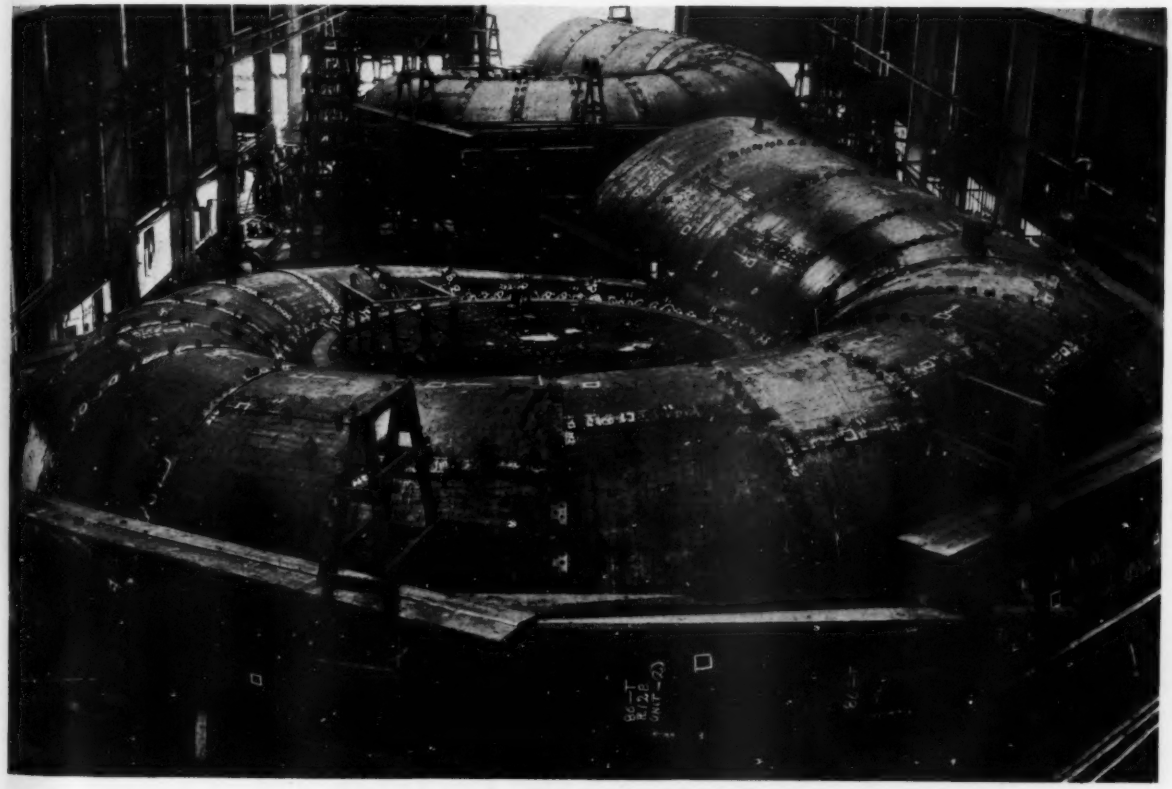
S.P.68



RUNNER FOR BUGGS ISLAND DEVELOPMENT

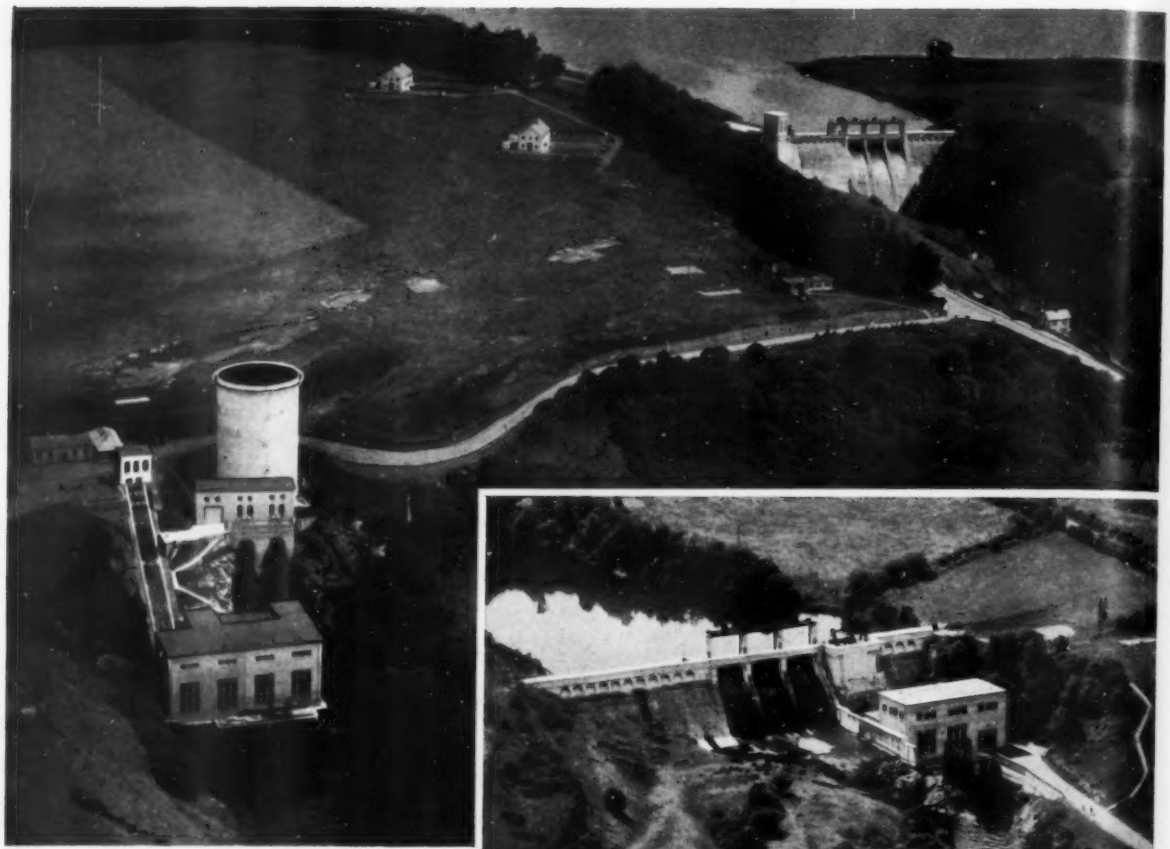
OVER EIGHT MILLION HORSEPOWER

The Newport News Shipbuilding and Dry Dock Company has received orders for the building of hydraulic turbines aggregate rated output of 8,135,000 horsepower.



ASSEMBLY OF SPIRAL CASINGS FOR C. J. STRIKE DEVELOPMENT

NEWPORT NEWS
SHIPBUILDING AND DRY DOCK COMPANY
Newport News, Virginia



THE LIFFEY POWER SCHEME FOR THE ELECTRICITY SUPPLY BOARD OF EIRE

The CEMENTATION COMPANY LIMITED

The works illustrated above are those of the Liffey Power Scheme for the Electricity Supply Board of Eire, built in the years 1937/43; a repeat order for the works of the Erne Hydro-Electric Scheme—a development of 75,000 kVA—is rapidly approaching completion.

The Cementation Company has had over twenty years' experience in civil engineering construction and has unique experience in tunnel driving and shaft sinking under the most difficult conditions.

Recent major contracts include the Clunie tunnel of the Tummel-Garry Hydro-Electric Development in Scotland—23 ft. equivalent internal diameter and nearly two miles long—the largest water tunnel in Great Britain; and an eleven mile section, wholly in tunnel, of the Haweswater Aqueduct for supplying water to the City of Manchester. On the latter contract, where conditions have proved to be exacting and arduous, scheduled progress has been maintained despite encountering heavy ground pressures and large water inflows of over two million gallons per day in one heading.

BENTLEY WORKS — DONCASTER

TELEPHONE : DONCASTER 54177-8-9

LONDON OFFICE 39 VICTORIA STREET, S.W.1 - TELEPHONE ABBEY 5726-7-8

Voith — Impulse Turbines

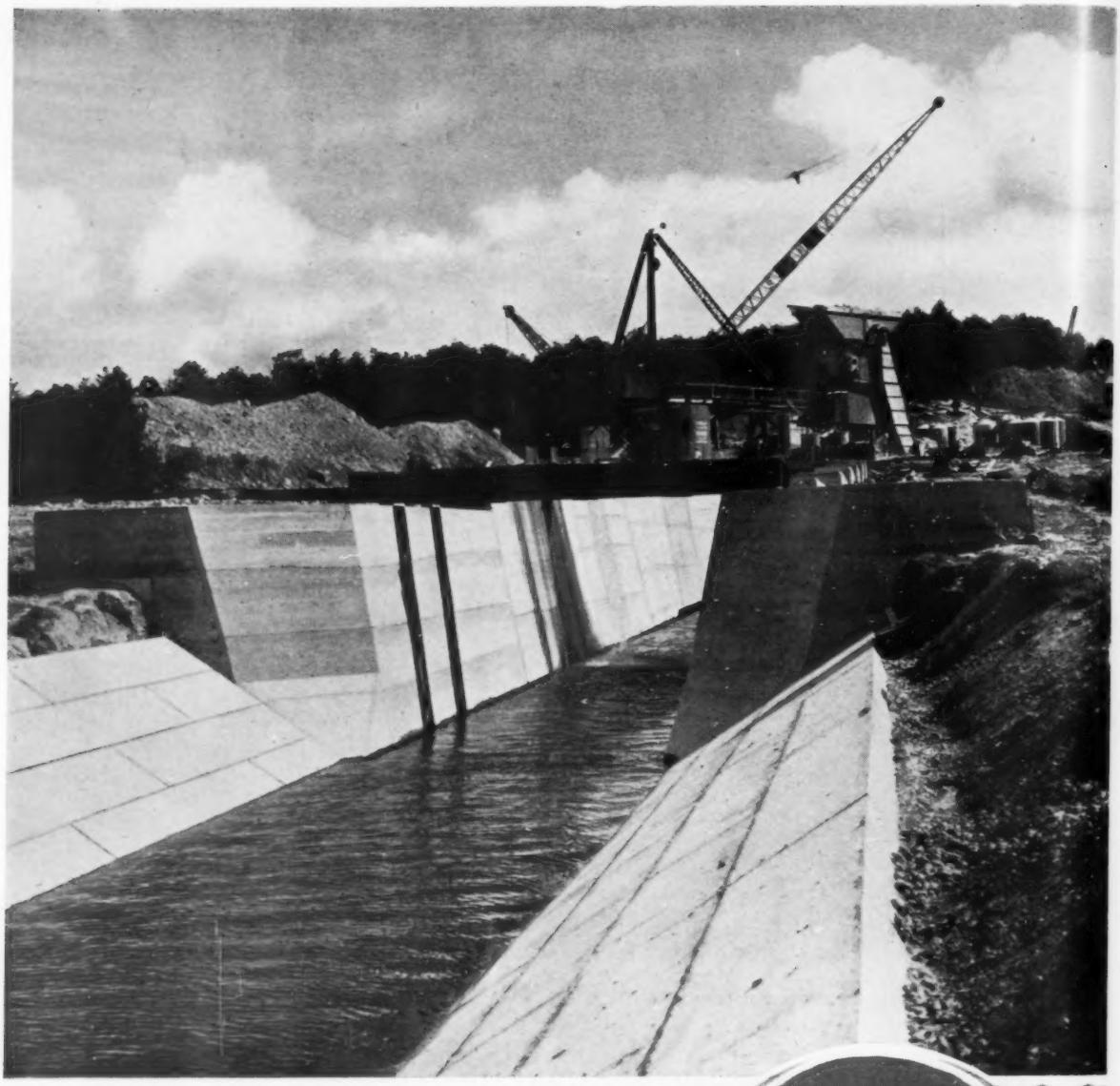
Workshop processing of big Impulse Turbine Runners

We have manufactured Impulse Turbines for **heads up to 3,313 feet,** and **unit outputs up to 85,000 h.p.**

Since 1947 we have supplied or have in manufacture 24 Impulse Turbines for unit outputs of above 500 h.p. for heads up to 2,558 feet and for a total output of about 530,000 h.p. among which are:

4 turbines, 51,000 h.p. each, for a head of 2,558 feet
3 turbines, 52,400 h.p. each, for a head of 1,187 feet

J. M. Voith G.m.b.H. **Engineering Works**
Heidenheim (Brenz), Germany



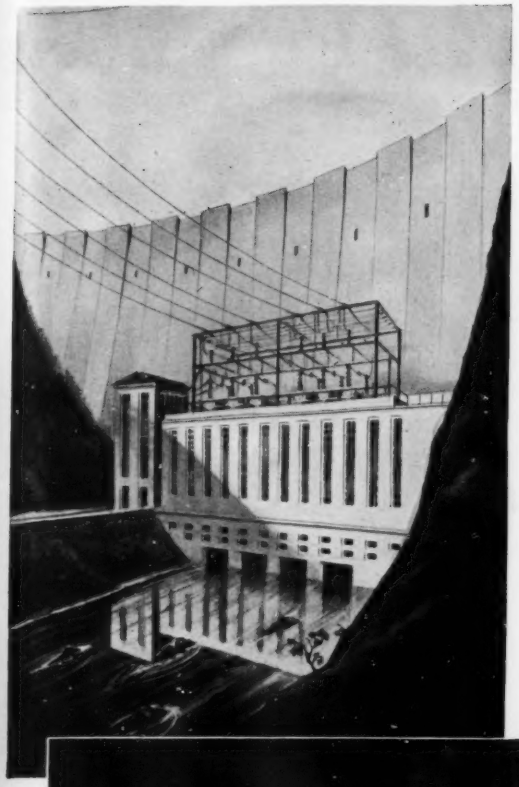
Work on the diversion tunnel and channel at the Weir Wood Reservoir Contract, which is one of the water conservation schemes being carried out by the Company

Consulting Engineers: Herbert Lapworth Partners

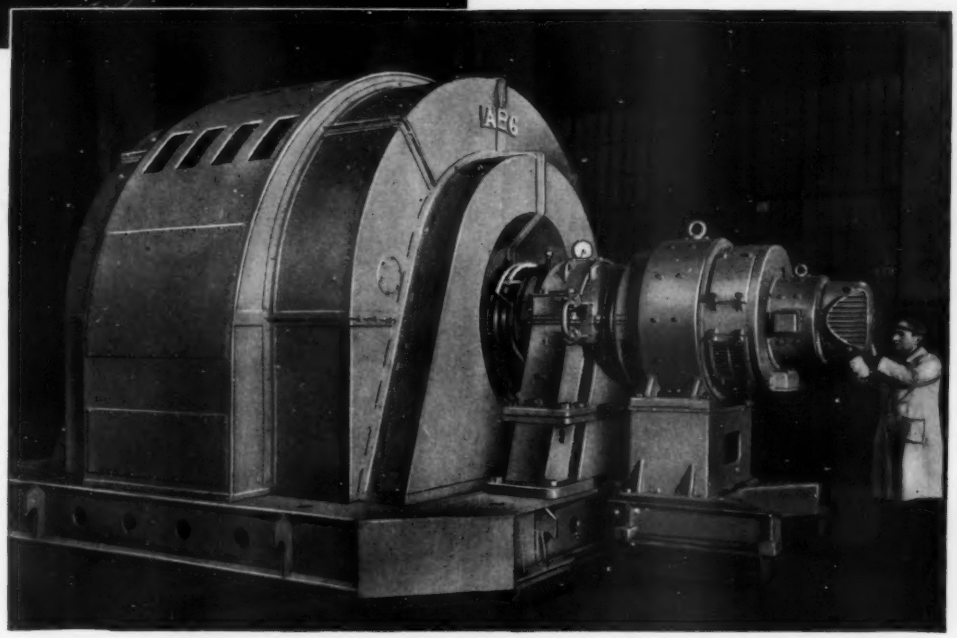
Richard
COSTAIN
Limited

LONDON S.W.I. VICTORIA 6624

Building & Civil Engineering Contractors



AEG
Water-Wheel Generators



24000 kVA, 600 rpm Generator on the test bed

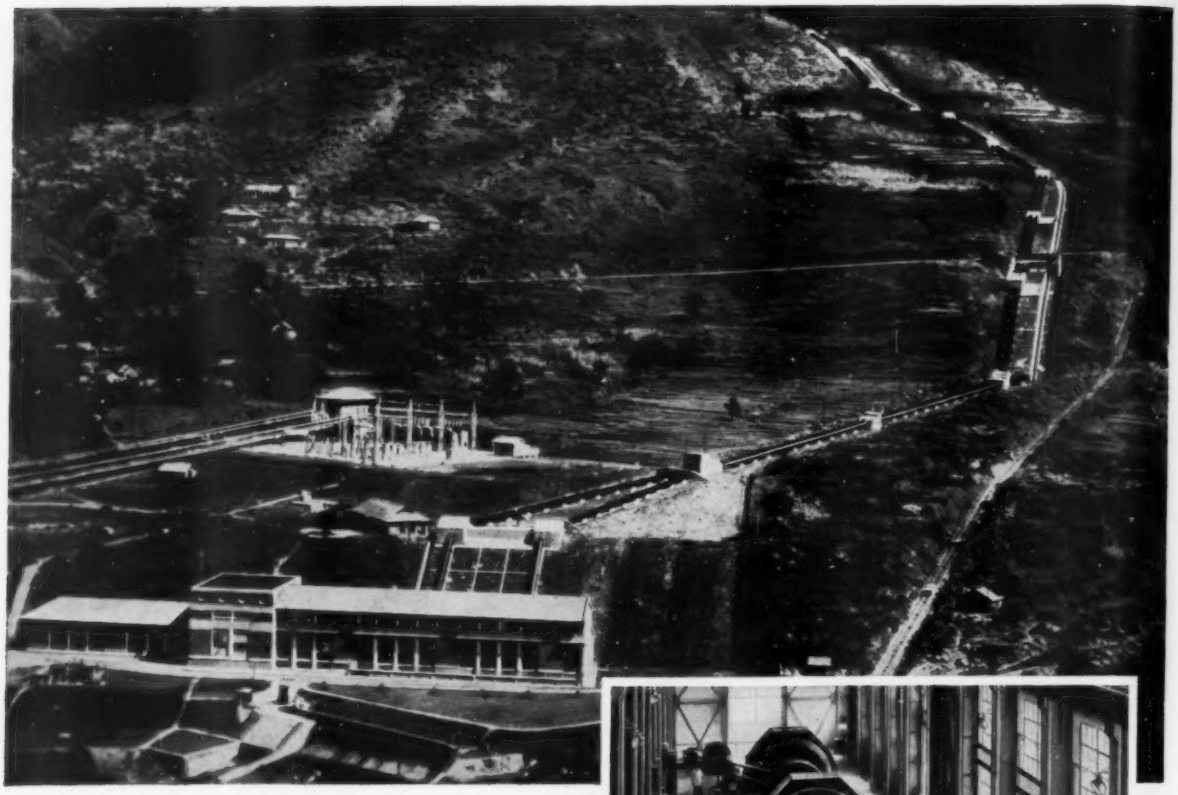
60 YEARS' Experience in Hydro-Electric Plants

5376

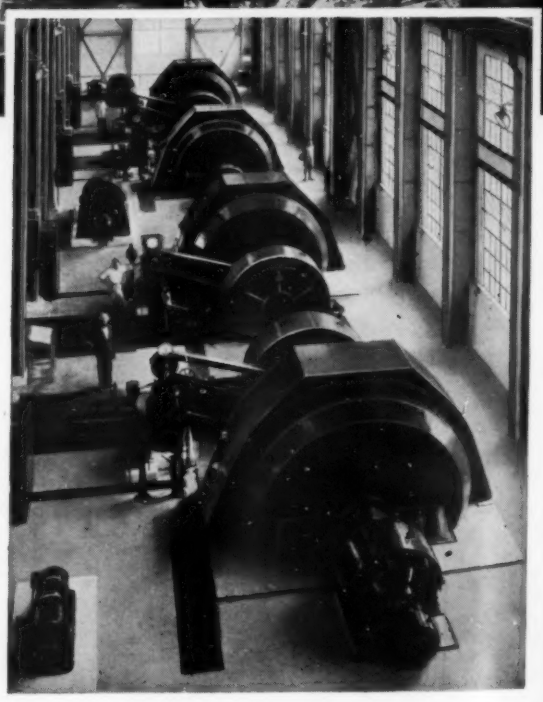
ALLGEMEINE ELEKTRICITÄTS - GESELLSCHAFT

Berlin-Grunewald · Export Department · Frankfurt a. M.

Hydro-electric Equipment



General view of Shanan Power Station



Four three-phase, waterwheel-driven alternators, (horizontal type, 13,333 kVA., 428 r.p.m., 11,000 volt, 50 cycle) installed in Shanan Power Station for the Punjab Government's Uhl River Hydro-electric Scheme.

For all plant required for
Hydro-electric Power Schemes
Consult BTH.

BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON CO. LTD. RUGBY, ENGLAND

Member of the AEI group of companies

A.3660

THE CLAERWEN DAM

for the

CITY OF BIRMINGHAM
WATER DEPARTMENT

Consulting Engineers

Sir William Halcrow & Partners M.M.I.C.E.

EDMUND NUTTALL

SONS & COMPANY (LONDON) LTD

Civil Engineering Contractors

22, GROSVENOR GARDENS, LONDON, S.W.1.

E.N.24

OFFICINE ELETTROMECCANICHE

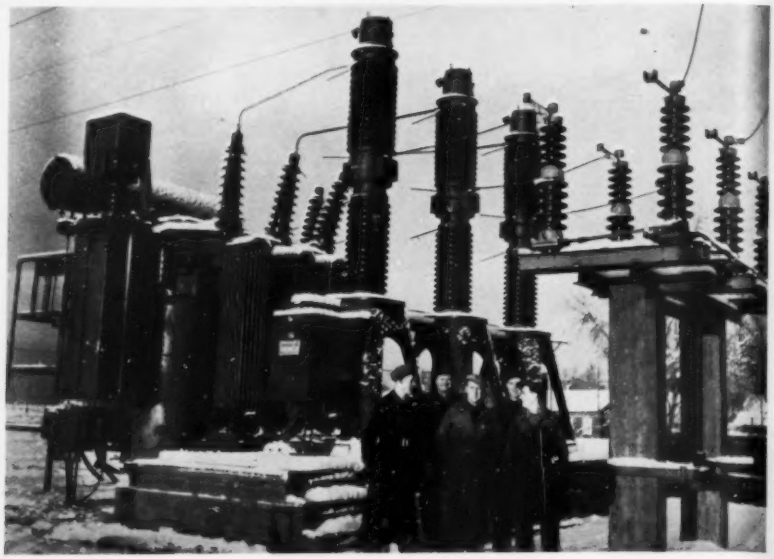
SCARPA & MAGNANO

SAVONA (ITALY)
Via Fiume, 2
CAP. L. 200,000,000
OFFICE IN MILANO
Via Revere, 14
Telegrams : Scarpamagnano

Switchgear:

CIRCUIT BREAKERS
ISOLATING SWITCHES
INSTRUMENT TRANSFORMERS
SWITCHBOARDS, ETC.

FOR BOTH INDOOR AND OUTDOOR SERVICE . . .
FROM **10** UP TO **220 KV**



Low Oil Volume 140 kV Circuit Breaker Type PO/143, supplied to Messrs. Rosenlaw & Co. Oy at Pori (Finland).

BPC

Measuring Equipment

FOR HYDRO-ELECTRIC PLANTS

WATER FLOW
in Tunnels, Pipe Lines and at Turbines.

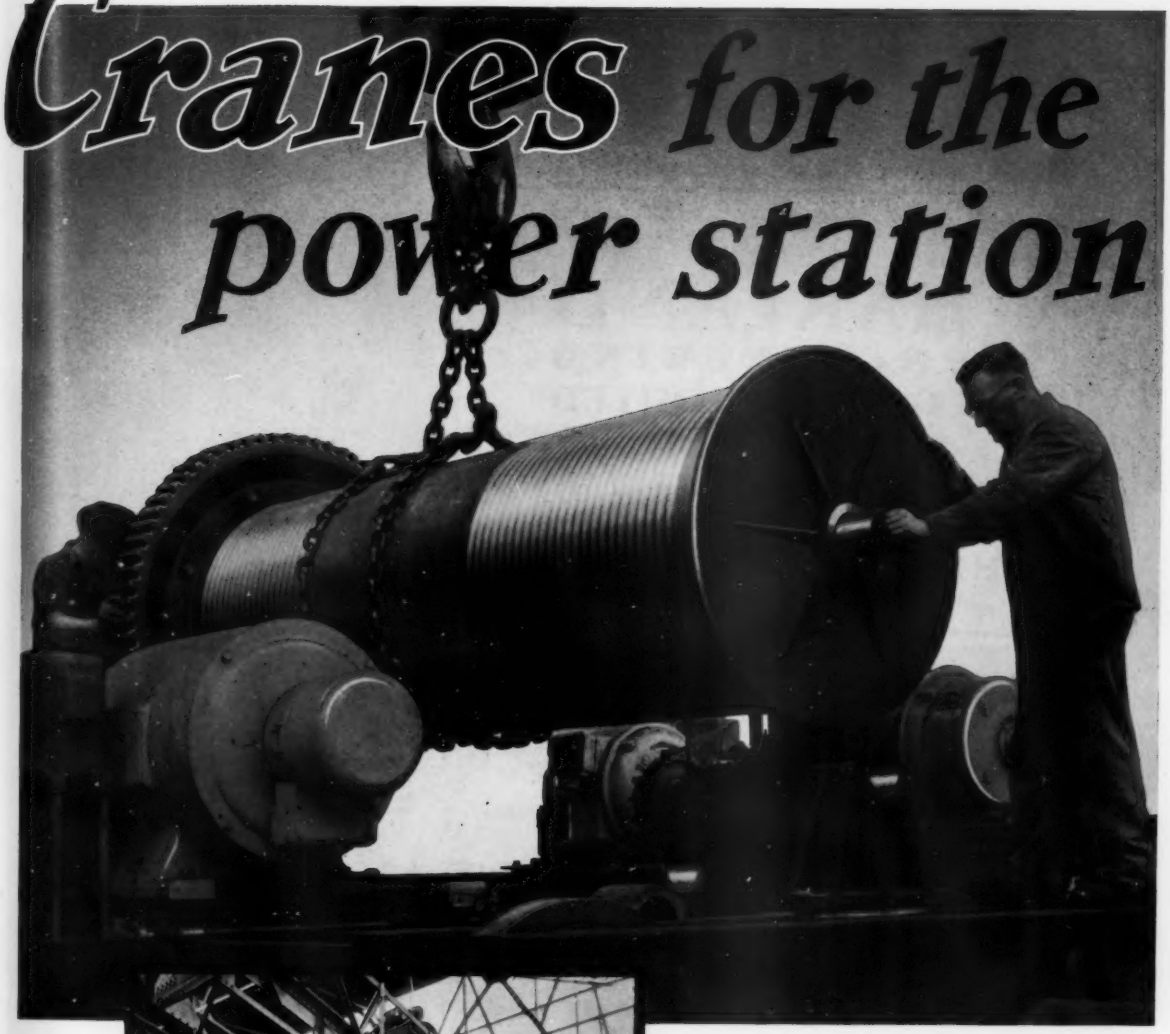
WATER LEVEL
at Dams and in Surge Shafts for all depths and conditions.

PRESSURE RECORDERS, *ETC.*
backed by over 20 years' experience in this specialised field, can be supplied for local or remote operation.

The illustration shows the type of Flow Meters now being made for the North of Scotland Hydro-electric Board.

The British Pitometer Co.Ltd
(ASSOCIATED WITH GLENFIELD & KENNEDY, LTD.)
105, PARK STREET, LONDON, W.1.

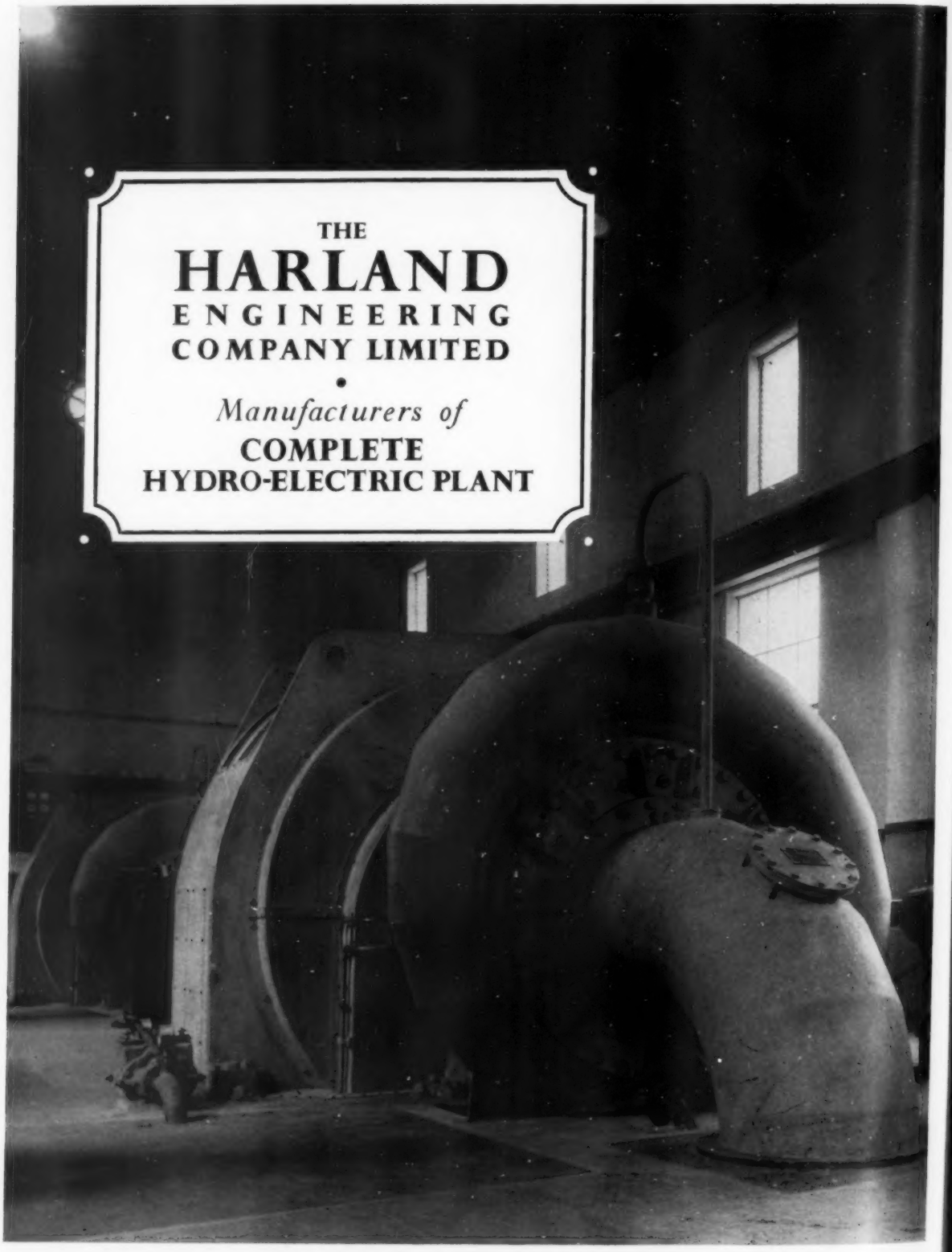
Cranes for the power station



THE massive rope drum for a 110-ton Morris crane is here shown being lowered on to the crab frame. Behind the drum is the crab traversing gear and the auxiliary lifting gear which in this instance is for a capacity of 10 tons. The crane was recently despatched to a hydro-electric power station in India —one more to the long list of Morris cranes already giving reliable service in power stations all over the world.

MORRIS

HERBERT MORRIS LTD., LOUGHBOROUGH, ENGLAND



Officially opened on September 26th 1951, the Loch Striven Power Station of the North of Scotland Hydro-Electric Board contains 2 - 4250 B.H.P. "Harland Morgan Smith" Francis Turbines driving 3000 K.W. "Harland" alternators—a fine example of hydraulic and electrical generating plant manufactured under one roof and erected at site by Harland specialist engineers.

THE HARLAND ENGINEERING CO. LTD., WORKS ALLOA SCOTLAND

WATER POWER

A technical journal devoted to the study of all aspects of Hydro-electric developments

Annual Subscription: 35 shillings. Single Copies 2s. 6d.

VOLUME 3. NUMBER 11.

CONTENTS FOR NOVEMBER, 1951

Leading Article: More Haste, More Speed - - 401

Editorial Notes - - - - - 402

International Power Exchange - - - - 404
By Rodolphe Leresche

Shire Valley Project - - - - - 410

Hydro-Electric Development in Uruguay - - 411
By Kenneth E. Sorensen

Fabrication of Water Mains - - - - 419
By P. L. Pocock

Correspondence - - - - - 423

Grudie Bridge Generating Station - - - 424

Book Reviews - - - - - 435

Fuluasou Hydro-Electric Scheme - - - 437

Abstracts from the World Technical Press - - 438

Published by
Tothill Press Limited,
33 Tothill Street, Westminster, London, S.W.1.
Telegrams: Ishbuilder, Parl, London. Telephone: Whitehall 9233 (12 lines).

MANCHESTER: Century House, St. Peter's Square. Telephone: Central 3101.
BIRMINGHAM: 90 Hagley Road, Edgbaston. Telephone: Edgbaston 2466.
NEWCASTLE-ON-TYNE: 21 Mosley Street. Telephone 22239.
GLASGOW: 87 Union Street. Telephone: Central 4646.
LEEDS: 70 Albion Street. Telephone 27174.

SHAWINIGAN
WATER & POWER COMPANY
Install
BICC CAPACITOR BANKS

This 15,000 kVAr bank of BICC Power Capacitors is installed on the electricity supply system of the Shawinigan Water and Power Company, Quebec Province, Canada. Comprising sixty 250 kVAr units—each a real engineering job—it operates at 11,750 volts.

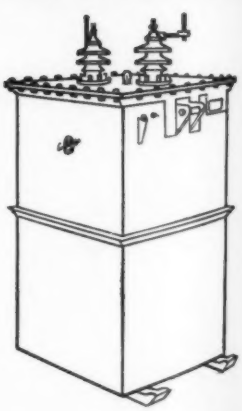
Another bank—20,000 kVAr—of BICC Power Capacitors for operation at 10,300 volts was recently supplied to the Aluminum Company of Canada.

40 years of development is behind modern BICC Power Capacitors. Therefore it is not by chance that they :-

- ★ **Are 99.87% efficient.**
- ★ **Have low temperature rise — 10°C.**
- ★ **Give many years of trouble-free service.**
- ★ **Normally require no maintenance.**
- ★ **Are simple to install (indoor or outdoor).**

Only BICC Power Capacitors offer *all* these advantages.

They can be connected in small banks at service points and secondary sub-stations, or in large banks at main sub-stations. Individual units are also available for connection at motor terminals and distribution boards.



Further information on the use of capacitor banks is contained in Publication No. 278V available on request.

B.I. Callender's

BRITISH INSULATED CALLENDER'S CABLES LIMITED
NORFOLK HOUSE, NORFOLK STREET, LONDON, W.C.2

Branches and Agents throughout the World.

WATER POWER

A technical journal devoted to the study of all aspects of Hydro-Electric Development

More Haste, More Speed . . .

IN nearly every department of human affairs, a survey of the last 50 years shows that planners have been too cautious and too timid. Increases of population have led to insatiable demands for every kind of service. There is seldom to be found a case where a public utility is able to meet the full present demands. Water, gas, housing, transportation, communications — all these provide examples in many countries.

The provision of electrical energy is no exception. Only two years ago, when the theory was first advanced in public conference that the rate of rise of demand was of an exponential nature, plenty of engineers were found who were ready to pour cold caution on this "assumption," to suggest that saturation might set in, that trade depressions might materially alter the curve, and that there might well be a period in the near future when supply would overtop demand.

The science of load forecasting is of recent origin, but a considerable bibliography of local and world statistics and forecasts has now accumulated. The events of the times support their conclusions, which are almost unanimous, that nothing appears to affect the rate of rise of electrical demand. The slope of the demand curve—which is the important criterion—continues to get steeper, in spite of wars and rumours of wars, vast industrial readjustments, real and threatened inflations, and every sort of political re-orientation.

Thus it would seem that the prime duty of those responsible for the installation of further power-producing plant must be to accelerate its completion. In regard to thermal power plants in Great Britain, the very reverse of acceleration appears to be happening; from a pre-war average time of three years to install a 120 MW station, the period has now risen to seven years, and there seems little likelihood of its being reduced. But hydro-electric engineers have gone some considerable way towards the acceleration of construction, though not far enough. The columns of WATER POWER have recorded, on many occasions, the progress made in mechanisation of constructional work, and in the design of dams in such a way that the tempo of the civil-engineering work can be greatly increased.

In America, for the smaller thermal units, a "package" type of power plant has been developed, so that a 10,000 kW power unit, complete with boiler, turbo-alternator, switchgear, and all auxiliaries, can be rapidly delivered and bolted down on any suitable site in a very short time. It is, of course, impossible to visualise a hydro-electric parallel; nevertheless, is it not true that many projects could have been completed much more rapidly if speed was the sole consideration — overriding finance, amenities, and the highest levels of theoretical efficiency? Prodigious civil-engineering works were completed during the war at unheard of speeds.

In one particular project, out of 365 days in the second year of the three-year completion period only 172 were working days, owing to extreme bad weather; and this project was in a temperate latitude. Is there not room for research on methods of preparing concrete which can be laid in conditions of extreme cold, for mechanisation to take the place of manual labour, and for concrete to be placed by methods that need not be impeded by heavy rainfall? Pumped concrete is no novelty to civil engineers, but remote control of the delivery pipe by servo-mechanisms, and possibly by the use of short-wave radio, has not, to our knowledge, been tried. The expenditure of 1 per cent. of the capital cost of an installation on equipment to allow work to proceed under any kind of adverse weather conditions might well be an investment which would pay handsome dividends.

The use of apparently unsuitable local material by altering the design, even though a greater bulk is needed to achieve a given factor of safety, might well avoid delays inherent in long transport lines, and obviate the time taken to set up conveyor flights, organise lorry trains, and perhaps to build costly roadways.

Young and keen civil engineers will be able to put forward suggestions whereby, through the operation

of methods that might be called revolutionary by the older generation, the lengthy process of building the civil works associated with hydro-electric schemes might be greatly shortened. The problem is of extreme urgency, as power shortage dislocates every aspect of modern civilised life.

Tasmanian Development

A REPORT submitted to the Government of Tasmania by the State Electricity Commission puts forward proposals for two new hydro-electric stations, one on the River Nive and the other at Lake Echo. The capital cost is estimated at £16 million. The station on the River Nive is to be situated at Wayatinah, upstream of the Tungatinah, now in the constructional stages and of course both plants will use the same water. The projected station will have a capacity of 140,000 h.p. derived from four, or possibly five, sets. The Lake Echo station will be situated on the Dee River which is fed from the lake and will have a capacity of 42,000 h.p. Here it is proposed that only one generating set should be provided.

This programme is not expected to be completed until 1957 at the earliest but it is hoped to have the Dee plant in partial operation two years before this date.

Large Hydro-Electric Contract for Portugal

THE English Electric Export and Trading Company Limited and Metropolitan-Vickers Electrical Export Company Limited advise us that they have successfully negotiated a million pound contract for the hydraulic, mechanical and electrical equipment for a new power station to be built by the Hidro-Electrica do Zezere, S.A.R.L., at Cabril, on the River Zezere, about 120 miles north-east of Lisbon.

The power station will be equipped with two hydro-electric generating units of 73,000 maximum horsepower each, together with ancillary switchgear and transformer equipment, all of which will be manufactured in Great Britain.

This contract, obtained against severe competition, follows one placed by the same undertaking with the above companies for a hydro-electric station at Castelo do Bode on the same river, and which formed the subject of an article published in the May-June, 1950, issue of WATER POWER.

New Hydraulics Laboratory

A PUBLICATION received from the Massachusetts Institute of Technology gives particulars of a new laboratory, the first part of which has recently been completed to afford additional research facilities for studying the mechanics of liquid flow. The laboratory is primarily designed for the pursuit of fundamental studies in the various branches of hydro-dynamics with a view to integrating new and existing knowledge into generally applicable principles. Immediate investigations will be concerned with the nature of surface resistance, internal flow patterns, turbulent flow and associated mixing processes, and other lines of study will deal with the formation of surface waves, the surface profiles in open channel flow as a function of boundary conditions, and with the forces exerted on immersed bodies with a view to elucidating the transportation of sediments in streams.

The building has been planned with a view to securing experimental flumes of adequate length, and proper consideration has been given to future extensions. To keep the floor space as flexible as possible fixed equipment has been kept down to a minimum, thus enabling an almost infinite variety of arrangements to be made to meet different needs. An area of 6,700 sq. ft. is available in the main hall and there is an additional area of 4,400 sq. ft. in the basement, exclusive of that taken up by the tanks. The provision of this additional space makes possible work which has been hampered for some time by lack of proper facilities.

Extensions to South American Plants

TWO orders have been received recently by Gilbert Gilkes & Gordon Ltd. for water turbines which will be paid for in Canadian dollars although they are not directly destined for Canada. Both have been ordered by the Montreal Engineering Co. for the Bolivian Power Co., South America. The first is a 2,000 h.p. pelton wheel operating under a head of 1,650 ft., which will form an extension to the existing Angostura Power Station. The second is a 3,500 h.p. pelton wheel operating under a head of 1,350 ft. and destined for Achachicala Power Station, where it will replace an existing turbine. The water supplying this power station is highly corrosive and contains free sulphuric acid. The turbine runner and inlet pipes will therefore be made of stainless steel and special precautions will be taken to avoid corrosion of all parts in contact with the water.

Venezuelan Development

A VERY considerable amount of hydro-electric development is under way in Venezuela, and is being carried out under the auspices of the Electricity Department of the Venezuelan Development Corporation (Corporacion Venezolana de Fomento). Electricity is not nationalised throughout the country and there are important private concerns operating supply undertakings in the capital, Caracas, and in other cities, while the petroleum companies also generate electricity in conjunction with the operation of their own plants.

The purpose of the Venezuelan Development Corporation is to supplement the output of these private companies, and to construct a grid network to reinforce the supply in areas where existing facilities are insufficient. The Corporation's current plans are divided amongst four regions, as follows:—

In the Western region there is a 30,000 kW hydro-electric development on the Uribante River at San Cristobal, together with other thermal and small diesel-electric plants.

In the Central region of the country, one small hydro-electric station is under construction with a capacity of 700 kW, this being situated at San Carlos. There is also a very considerable amount of steam and diesel-electric power plant scheduled for completion within the next few years, in this region.

In the Eastern region of the country there is no hydro-electric development, although a considerable amount of steam power plant is scheduled for commissioning within the next four years, but in the South-Eastern area a very large hydro-electric de-

velopment, centred on the Caronia River, is under consideration.

The first power plant on this river, which flows from the highlands of the Venezuelan Guayana into the river Orinoco, just below the city of Ciudad Bolivar, is a 50,000 kW plant to be erected at San Felix. This is scheduled for completion by 1955, but a very large plant with an ultimate capacity of 200,000 kW is also part of the scheme.

As the Guayana highlands contain vast deposits of minerals of many kinds, including very large amounts of iron ore, it is the Government's intention to foster plans for a new industrial development, including a steel plant and an aluminium smelter, to be supplied with electrical energy from the Caronia River power plants. At present, rainfall and flow measurements in the Caronia River basin are being undertaken with a view to finalising the plans for this very large hydro-electric development.

New Departure in Load Despatching

ACCORDING to the Canadian Correspondent of the *Financial Times*, the Aluminium Company of Canada are adopting the use of a new technique in load despatching in connection with their hydro-electric stations. It is understood that a single micro-wave ratio circuit will interconnect the four Alcan power stations situated respectively at Shipshaw, Isle Maligne, Chute-du-Diable and Chute-a-la-Savane and that it will be possible thereby to conduct several telephone conversations simultaneously. Furthermore, additional connections to Chute-du-Diable and to Chute-a-la-Savane will be used for telemetering purposes. All the circuits are to be terminated in telephone switchboards in each power house and will be operated in the same way as wired circuits. The great advantage of the micro-wave system is that it will provide complete protection against disturbances and bad weather conditions.

The equipment is being supplied by the Canadian Marconi Company and is expected to be in operation in the early spring of next year.

A Notable River Model

THE Fraser river constitutes one of the most important drainage systems in British Columbia and the Strait of Georgia, into which it discharges, has a tidal range of 14 ft. Wide variations occur in the discharge rate which ranges between 17,000 cusecs during the winter to 200,000 cusecs in the May to July freshet period, with maximums of 536,000 cusecs. Enormous quantities of sand are transported along the bed, forming waves or dunes in the estuary and creating tidal flats at the river mouth. Plans to widen and deepen the main channel in order to increase the navigational facilities have engaged the authorities for some years, but have not hitherto materialised because of the uncertainty of the consequences which would result to the navigable channels. To enable correct dimensions to be determined and to ascertain the most economical means of obtaining a well-proportioned main channel, a large model has been constructed under the aegis of the National Research Council of Canada. Some of the overall dimensions of the model are of interest; the site covers 3·67 acres and has been constructed to a horizontal scale of 1 : 600 and a vertical scale of 1 : 70. The total water surface amounts to 22,730 sq. ft. and the total quantity of sand in use in the channels and tidal flats is 700 cu. yards. The channels approach 500 ft. in length and the pumping services are able to handle up to 20 cu. ft. per sec. for the simulation of tides and 2 cu. ft. per sec. for the river discharge.

Water Power Schemes as a Tourist Attraction

THE water-power schemes in Scotland have rightly become "tourist" centres in the sense that distinguished overseas visitors are frequently seen at one or other of the hydro-electric plants. Visiting editors and journalists have had the water-power centres included on most itineraries. Now, however, a proposal has been made by a Co-operative Society group that 'bus tours be run to the main schemes. This marks a new and interesting mental reaction. Although the hydro-electric power schemes have had ample publicity and are associated with the revival of the Highlands, and that they have a glamour absent from some other industrial projects, the idea of running 'bus tours to see industrial projects is something new. In this instance the interest in hydro-electric power appears to have been fostered by local organisations rather than from the actual promoters. A considerable number of requests had been made for facilities to visit the schemes from Edinburgh, the Association stated in their application. Water power as a tourist lure may well be something that can be developed although undue popularity of these tours might lead to difficulty in maintaining normal routine functioning. We might thus picture the staff either giving up in disgust or becoming glamour boys under the continuing adoration of visiting tourists. Seriously, however, this development is one that emphasises again the appeal that water-power projects possess for the public at large.

Hydro-Electric Progress in Eire

ACCORDING to the Electricity Supply Board's report for the year ended March 31, 1951, the Shannon scheme gave its highest output ever recorded at 388 million kWh. Nearly half of the electricity generated in Eire for this year was produced in hydro-electric plants, which furnished 466 million kWh out of a total of 969 million kWh. A capital development programme involving an expenditure of £30 million over the next five years is in hand for an additional 270,000 kW to be derived partly from thermal stations and partly from hydro-electric developments on the River Erne and River Lee.

No Parking for Birds

ENGINEERS on the Davis Dam Project of the United States Bureau of Reclamation have been troubled by short-circuiting of their transmission lines by flocks of migratory birds. Accordingly they have fitted about 2,000 sets of aluminium guards to their 964 transmission towers. These guards are bolted between members of the tower cross sections and are armed with sharp teeth bent to a business-like Y shape. We imagine that these guards will prove rather baffling to the birds but they will at least have the satisfaction that it is better to be baffled than electrocuted.

International Power Exchange

Technical and economical aspects of international interconnections, realized between Switzerland and adjoining countries.

By RODOLPHE LERESCHE

DURING the last hundred years accelerated technical progress has provided man with new and precious tools, without which his present achievements would not have been possible. This development, which is now a predominant factor in the civilised world, received its main impetus through the industrial utilisation of electricity. The consumption of electric power, which seems far from having reached its saturation point, will most probably go on rising in future.

Every nation endeavours to cover its requirements with every means at its disposal. The number of thermo-electric plants increases steadily in countries rich in coal and lignite, whereas hydro-electric plants are constructed where water power is abundant.

Both these means of production have their own distinctive characteristics, with their respective advantages and drawbacks. Thermo-electric plants can be built close to centres of consumption, which is a great advantage; however, it has to be considered that the deposits will be gradually exhausted so that it will be necessary to dig the mines deeper and deeper and to extract the coal with ever-increasing costs. Hydro-electric plants are first of all dependant on the geographical situation of the water power source which is often located very far from the load centre. Low-head river-flow plants generally have to work with a very variable discharge, and it is therefore necessary to build supplementary high-head storage plants to run in conjunction with them and this considerably increases the capital cost.

These considerations logically lead up to the idea of an exchange of energy between networks fed by thermal and hydro-electric plants respectively. By keeping a certain balance of output and operating periods it is possible to utilise the available water

Fig. 1. The Ryburg-Schwoerstadt Power Plant, situated on the Rhine, the northern boundary of Switzerland, forms an important point of interconnection. With its four generating units of 27,000 kW each, i.e. a total of 108,000 kW, a power export is easily realised by putting one or both of the two units normally working for Switzerland on foreign networks

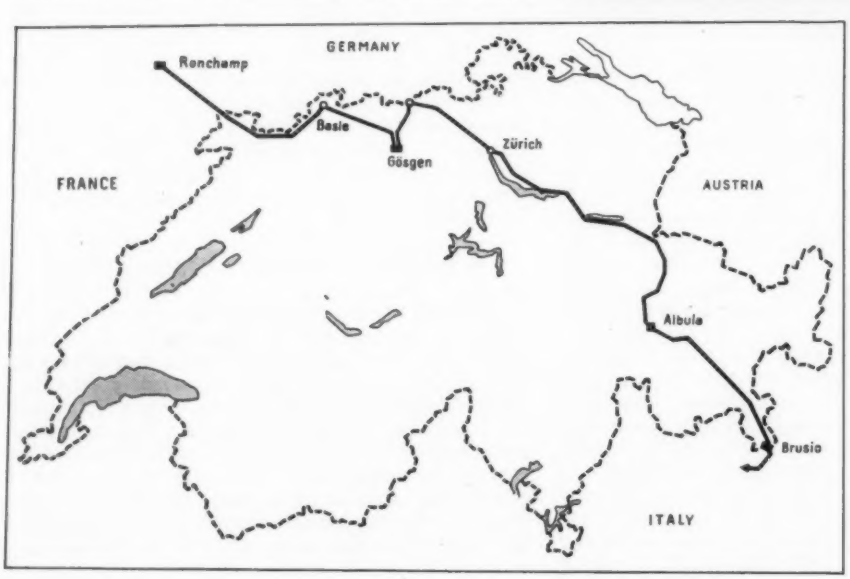


Fig. 2. Power transmission from France to Italy across Switzerland, realised in 1922

power in a more efficient way and to save a considerable amount of fuel at the same time. Thanks to the economic advantages of the combination of thermo-electric and river-flow plants, the economy of the production as a whole can be improved.

Switzerland is the ideal water-power country. This

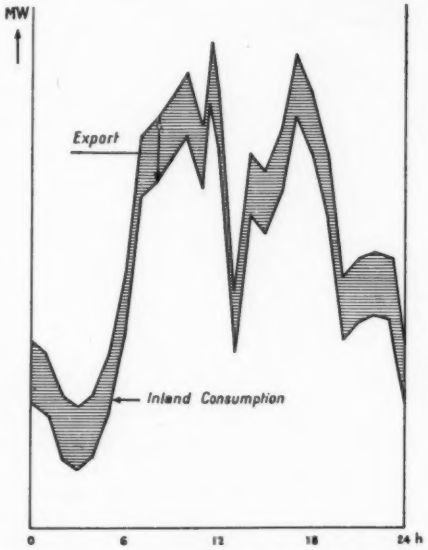


Fig. 3. 24-hour load diagram of the transalpine St. Gotthard line, showing constant flux of exported power as difference between transmitted power and inland consumption

circumstance has largely contributed to the rapid development of her electrification, based practically on water power only. But the variations of the discharge during the year, and from one year to another, have made it necessary for the power companies to construct their plants in such a way that the production will be able to meet the demand, even during the low-water period of an extremely dry year. For the rest of the time, therefore, the producers dispose of a variable power surplus which can be utilised in electric steam boilers, thereby temporarily replacing fuel, and which is also suitable for export.

This was how the export of energy was first started. From year to year the interconnections with the neighbouring countries have been steadily developed and certain plants have even been specially constructed for the exportation of electric power. These generating stations are usually situated close to the border and connected directly with foreign networks or consumers by means of power transmission lines across the frontier.

Besides regular supplies, based on long term contracts, there are also frequently short-term supplies or even occasional exchanges due to temporary requirements. Like sailors and fishermen who unite their efforts in their struggle against the elements, electrical engineers also show a good team spirit, being always willing to give a helping hand when thunderstorms, tempests, breakdowns or merely a power shortage puts one of them in a difficult situation. They are always ready to unite against adversity, even beyond frontiers.

In 1922, at a time when the transmission lines did not yet have a large capacity, a good illustration of this team spirit was afforded by the transmission of power from France to Italy, across Switzerland, a distance of nearly 200 miles (Fig. 2). At that time there was a shortage of winter energy in Italy. The French network of Ronchamp, which normally imported hydro-electric power from the Swiss generating plant of Goesgen, renounced this supply by putting its thermo-electric plant into operation. The power thus liberated was sent to Zurich, using another network as an intermediary. Zurich was then able to put a generator of the Albula Power Plant in the Alps in parallel with the Italian network by means of the transmission line across the Pass of Bernina. These were essentially makeshift methods, but the results were good, considering the feeble capacity of the transmission lines available at that time.

With technical progress, the possibilities of interconnection were greatly enhanced, and thanks to higher voltages and larger generating stations, power exchange between countries has been realised on a bigger scale. From 1930 to 1940 considerable quantities of energy were sent abroad. The Swiss undertakings, who had constructed several large generating stations, had at their disposal an appreciable reserve of power, an excess of energy beyond the needs of the country. For several consecutive years it was thus possible to maintain an annual exportation of more than 1,500 million kWh. The energy was sold according to contracts concluded after free negotiations

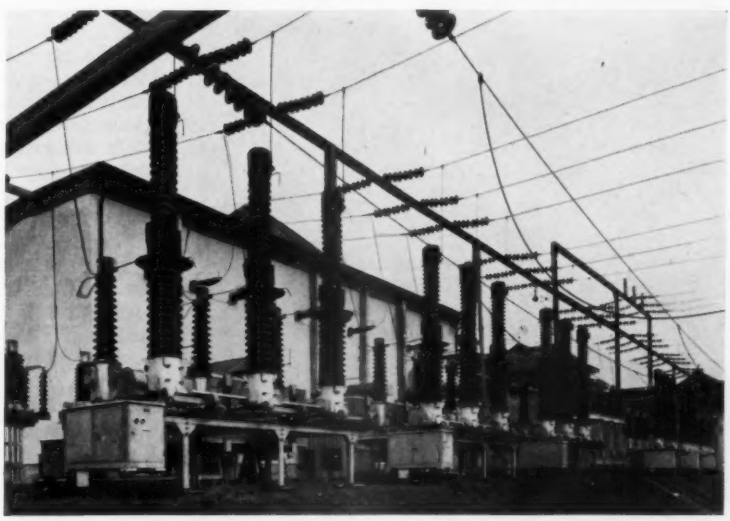


Fig. 4. A considerable part of the power exchanged between France and Switzerland passes through the Bottmingen Substation situated close to the border near Basle

between the interested companies. These exchanges constituted economic advantages for the countries in question—Switzerland on the one hand and Germany, Italy and France on the other.

The broad policy of extension followed by the Swiss companies during this period, created a considerable excess of generating capacity. Later, from 1939 to 1950, this circumstance made it possible to meet the most important home demands. By restricting exportation and even cutting it out completely at times, appreciable quantities of energy were held in reserve and liberated to meet the needs of industries and householders who were severely handicapped by the curtailment of fuel importations, occasioned by the hostilities.

During this period, the exchange of energy, which did not cease on account of such difficulties, took a different aspect. The currency difficulties and the lack of clearing arrangements made it necessary to go back to a primitive barter system. By sheer necessity various agreements of great diversity were brought into being. The power companies showed an extraordinary flexibility in facing the difficult situation in which they found themselves.

It was largely a question of finding solutions which would give concrete advantages to both parties. In one instance, the Swiss power company offered energy which it would have normally sold for steam raising in inland electric steam boilers, so saving 0·35 to 0·4 pounds of coal per kWh. By purchasing this energy, the foreign company, who produced electricity with steam power plants, could save 1·1 to 1·3 pounds of coal per kWh. A contract stipulating an exchange of 1 kWh for 0·7 to 0·8 pounds of coal was therefore very attractive for both parties. During several months electricity was thus exchanged for wagons of fuel from France. There was no payment, no clearing, merely a bilateral exchange.

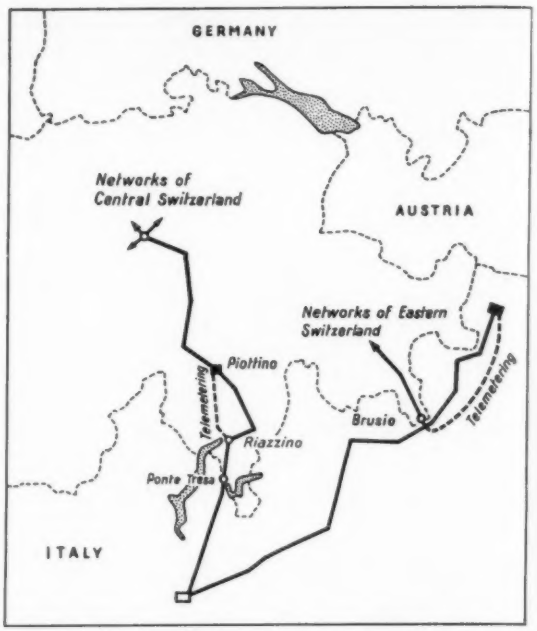


Fig. 6. Power importation from a hydro-electric plant in Italy. By the aid of telemetering installations, two-thirds of the energy is imported at Brusio and the remaining third over Riazzino

Fig. 5. From the Piottino Generating Plant, which is situated near the southern junction of the transalpine lines, power exchange is regulated by means of carrier current telemetering equipment

On another occasion, a foreign power company was supplied with a whole generating unit destined for a thermo-electric power station, with boiler, steam turbine and alternator. The Swiss industry was repaid in the form of electricity in course of the years which followed the inauguration of the unit. In this case, as in the former, there was no payment made by one country to the other, and on this barter basis an arrangement was easily reached.

Still other arrangements were in force whereby summer energy was given in exchange for winter energy, keeping account of the relative market values of the respective categories—for instance 3 kWh in summer for 1 kWh supplied in winter. Day-time energy was also exchanged for night-time energy, and there were, of course, numerous other arrangements.

All these agreements, several of which are still valid, show that the electric power companies were not deterred by obstacles. In spite of all sorts of difficulties they kept in contact, thereby ameliorating the adverse economic situation.

After this brief survey of the many problems of international connections, seen from an economical point of view, it is of interest to consider the technical aspects of this exchange.

For a distance of more than 60 miles the Rhine constitutes the northern boundary of Switzerland. Both in regard to fall and volume, this river is admirably suited for the mass production of electricity.

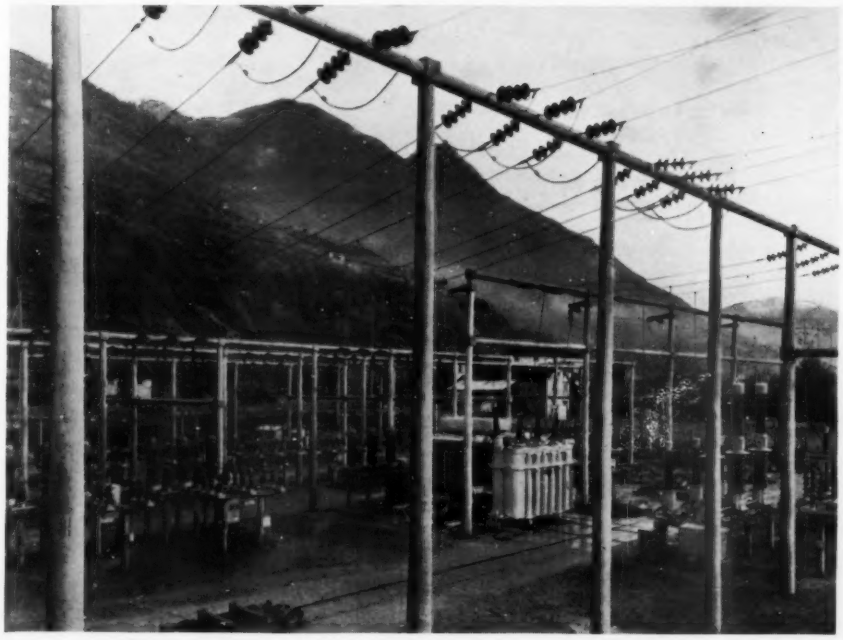


Fig. 7. The Riazzino Substation near the Italian border has a framework of centrifuged concrete pylons

Fig. 8. The 380 kV Lavorgo — Amsteg Line, which follows the Lucmanier Pass and crosses two mountain ranges at an altitude of 8,200 feet, constitutes an important transalpine connection

Numerous power plants, such as Reckingen, Albbrugg-Dogern, Laufenburg, Ryburg-Schwoerstadt, Rheinfelden and Augst-Wyhlen, have been constructed for the exploitation of international concessions. Situated on the very border, these generating stations also provide important points of interconnection, since each of the adjoining countries is entitled to half of their production.

Let us for instance consider the typical case of the Ryburg-Schwoerstadt Power Plant, Fig. 1, which has four generating units of 27,000 kW each, i.e., a total of 108,000 kW, with an average annual production of approximately 750 million kWh. Normally two of the units produce current for Switzerland, but in summer, when there is a surplus hydraulic production in that country, a power export is easily secured by connecting one or two Swiss units to foreign networks. In order to facilitate power exchange, however, the installation has been completed by a transit transformer with a capacity of 60,000 kVA and three separate windings—one for the generator voltage and the two others for the operating voltages of the connected networks.

For the importation of thermo-electric power in winter time, which are based on contracts with the Rouen Power Plant in France and constitute a method of payment for supplies of electrical equipment, the generating station in question places its power at the disposal of the French network, which will renounce hydro-electric power from the French Rhine plant at Kembs, near Basle. Kembs will then be switched on Ryburg-Schwoerstadt and will work separately on the Swiss network. In this case there is no "metallic contact" between producer and consumer. The interconnection is made by an indirect exchange, since the distance between Rouen and the Swiss border (about 300 miles) is too long to make a direct power supply economically feasible.

If it is not possible to obtain a separate service with the available equipment, the engineers are obliged to find other technically practicable solutions. A Swiss power company, for instance, contemplates a power exportation for France which will be derived from the summer energy produced in the Piottino Generating Station south of the Alps. The contract provides for a constant flow of power. However, the north-south transmission line, which crosses the Alps at St. Got-

thard at an altitude of 7,200 ft., is also used for supplying the Swiss network north of the Alps (Fig. 3).

In the Bottmingen Substation at the border, close to Basle, telemetering instruments, which will transmit an indication of the exported power to the Piottino Generating Station, are therefore installed, in addition to the normal measuring instruments (Fig. 4). The control post of Piottino is then able to regulate its total power production in such a way that the power exported to France will have the required value at any given moment (Fig. 5). This value is equal to the difference between the power actually produced and the power consumed on Swiss territory.

There are still more complicated cases where several companies have to participate in the regulation of power exchanges. Let us for instance consider an interesting case where Switzerland, who has granted a loan to a great hydro-electric scheme in Italy, is reimbursed in the form of kilowatt-hours, that is, as importation of winter energy; this arrangement is still in force. The power enters Switzerland in two places (Fig. 6). On the Italian side, the generating station itself is regulated in such a way that two-thirds of the power is transmitted to the Brusio generating station which in turn passes it on to two Swiss networks. The regulation of the remaining third, which is imported over Riazzino, devolves upon the Swiss. By the aid of telemetering indications, communicated by carrier current, the Piottino power plant, which is working in parallel on the Italian line, regulates the production so that the importation corresponds to the predetermined programme (Fig. 7).

These were only a few cases chosen to illustrate the various possibilities of power exchange. A number of further examples could still be added, since the

Fig. 9. The Amsteg—Mettlen Line is operated at 150 kV, but the towers and their foundations have been provided for a voltage of 380 kV. When equipped with conductors and insulator chains for this voltage, this line will have a capacity of nearly 1 million kW

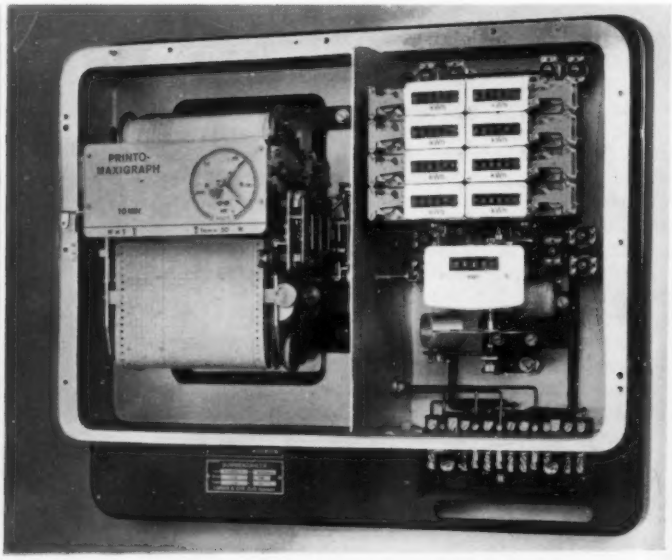


Fig. 10 (left). Transmitting station of a simultaneous remote control and telemetering installation (Landis & Gyr SA. Zug)

Fig. 11 (above). "Printo-Maxigraph" printer and recorder, combined with a meter showing energy received or supplied by different networks (Landis & Gyr SA. Zug)

production of the generating plants, and thereby the whole power market, depend on the discharge of the rivers which in turn is subject to rapid changes in the meteorological conditions. However, these few cases should give an idea of the various ways in which interchanges between Switzerland and the neighbouring countries are effected.

These exchanges are the fruits of a sound economy and were made possible by the bold construction of transmission lines of large capacity. Even as early as 1932, Motor-Columbus constructed a powerful north-south transmission line across the Alps, following the line of the St. Gotthard Pass. At present, it is operated at 150 kV, but the towers and their foundations have been provided from the very beginning for 380 kV. This line has recently been supplemented by a new transalpine line which follows the Lucmanier Pass and crosses two mountain ranges at an altitude of 8,200 ft. (Fig. 8). In order to obtain a higher degree of operational safety, a different route has been chosen for the new connection, the towers of which have also been designed for 380 kV and constructed in accordance with the Motor-Columbus system of using concrete-filled steel tubes. These lines, which have been extended northwards as far as Mettlen, near Lucerne, and which will soon be extended southwards to Riazzino, near Locarno, both belong to the Aar-Tessin Electric Power Company Ltd. (Atel). Later, when this double line is equipped for a voltage of 380 kV, which will make it necessary to prolong the insulator chains and replace the existing conductors by hollow core cables, it will have a capacity of nearly 1 million kW (Fig. 9).

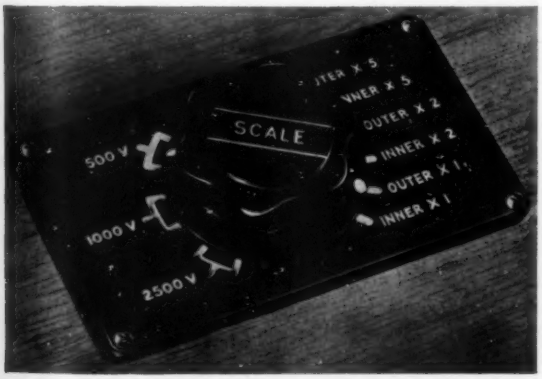
As for the measurement of power exchanges across the frontiers, it does not present any special features; indeed, the metering procedures hardly differ from those for inland supplies. On the Swiss side, the authorities only prescribe the use of a load recording instrument besides the normal watt-hour meter. These instruments are not installed at the frontier itself, but in a substation situated close to the border.

With the steady increase of the power to be transmitted it is important to have measuring instruments with the highest possible accuracy. The manufacturers who specialise in measuring instruments constantly endeavour to increase the precision of their apparatus, and in the field of telemetering and remote control, great progress has also been made (Fig. 10). Thanks to the development of new instruments it is possible to solve the ever more complicated problems of interconnection (Fig. 11).

This brief survey should give an idea of how the various possibilities of power exchange have been realised. For the moment, the interconnections are, in general, only peripheral, i.e., they are only made between great networks at their mutual borders, but exchanges over much larger distances have already been effected, such as transfers of power from Holland and Western France to Switzerland. Let us hope that some day international trade will be less hampered and that a full and free exchange will once again be established. This would greatly facilitate international exchanges and create a better economical balance in Western Europe between hydraulic and thermal production in the regions concerned.

Six Range "Megger" Tester

Evershed & Vignoles Limited, of London, have recently introduced a new version of the well-known "Megger" insulation tester. It is very similar in external appearance to the ordinary Series-1 instrument, but has the advantage that it can be operated with three voltages to give six ranges of indication. This is achieved by the provision of a six-position range switch. Tests can thus be taken on 500 V within the ranges of either 0 to 50 megohms or 3 to 10,000



megohms; on 1,000 V the ranges are 0 to 100 and 5 to 20,000 megohms, and on 2,500 V either 0 to 200 or 15 to 50,000 megohms. This development was exhibited for the first time at the recent Physical Society's Exhibition and the adjacent illustration shows the six-range switch. Other exhibits of this company included a new quick-response recorder having a maximum sensitivity of ± 1 millivolt on a.c. or d.c. Its recording movement incorporates a two-phase induction motor instead of the moving-coil movement used in previous instruments which had a sensitivity of only ± 10 volts, d.c. A drag-cup generator coupled to the movement facilitates variable damping. The new recorder, which will follow frequencies up to 10 cycles per second, is intended for working from high-speed thermo-couples or from strain gauges.

Delays in Hydro Schemes

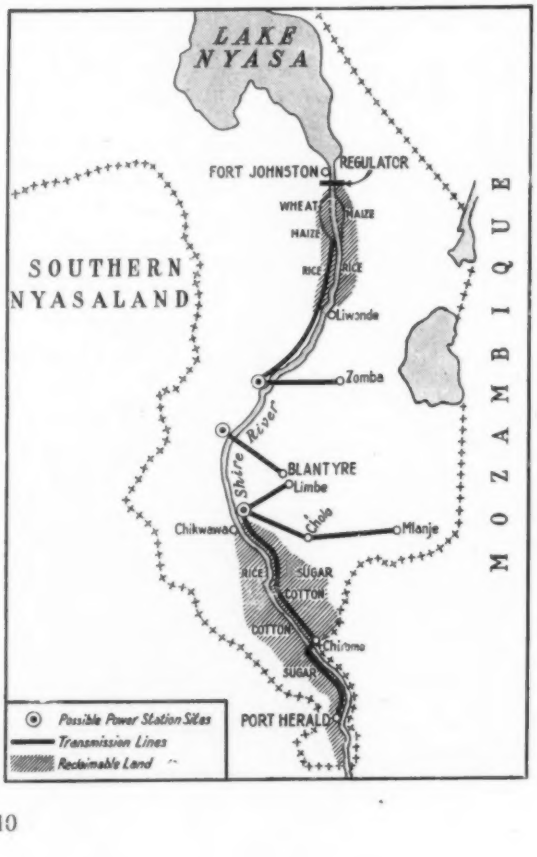
The importance of water power as one of the few remaining sources of new wealth in Scotland was stressed by Mr. W. D. D. Fenton, secretary of the North of Scotland Hydro-Electric Board in a recent address to the Town and Country Planning Association. He estimated the power potential to be about 10,000,000,000 units per annum, or twice the present annual consumption of all classes of users in Scotland. In the Board's area, he stated, power consumption had risen 20 per cent. against the same period last year and was conclusive evidence of a growing demand for electricity. One point he made deserves to be specially stressed. Despite the paramount need for new power sources, no less than five Ministries had to be consulted before a power plant site could be approved. Objection by one could create a delay which slowed down the whole tempo. The argument that amenity must be preserved has also contributed to delay in the erection of transmission lines.

The Shire Valley Project

THE waters of lake Nyasa have their natural outlet in the Shire river which in turn flows into the Zambesi river. From the lake the river traces a course of some 220 miles, falling from 1,500 to 120 ft. above mean sea level. The greater portion of this fall is concentrated in a 50-mile central section which consists of a series of falls and rapids. The remainder of its course in Nyasaland is through broad low-lying valleys, a considerable portion of which are subject to seasonal flooding.

Both lake Nyasa and the Shire river are of great importance to the economic development of Nyasaland, but the vagaries of their behaviour have in the past made it impossible to secure the benefits which might otherwise have been obtained from their use. For many years the Government of Nyasaland has had under consideration the possibility of artificial stabilisation or control of the level of the lake and the use of the waters of the Shire river for the production of hydro-electric power and for irrigating the lands in the Lower Shire valley.

In 1944, Dr. Kanthack of Johannesburg investigated the problems involved in the control of the lake level, and in 1946 Professor Debenham of Cambridge University paid a short visit to Nyasaland and made a further examination of the position. In the same year, Mr. A. E. Griffin, late Director of Irrigation in the Sudan, made a preliminary survey of the lake and river which provided a valuable indication of the problems that would arise and the nature and extent of further investigations which would be necessary before a scheme could be formulated.



As a result of these investigations the Nyasaland Government appointed an irrigation engineer in 1948 to carry out a general survey on the lines recommended. The survey showed that the control of the waters of the lake and river was feasible and that these waters had great economic potentialities, both from the point of view of the production of hydro-electric power and for irrigation. As a result of this work, the Nyasaland Government has recently decided to appoint the firm of consulting engineers, Sir William Halcrow and Partners, to undertake a full-scale survey which will cover all aspects of the project—planning, engineering, economic and financial. This survey, which is known as the Shire Valley Project Survey, will probably take two years or more.

The survey as at present envisaged will cover the following:—

(1) The control of the level of lake Nyasa and the regulation of water to the Shire river by the erection of a barrage on the Upper Shire.
(2) The use of the Middle Shire for generation of hydro-electric power.
(3) Irrigation and reclamation of large areas of land mainly in the Lower Shire valley.

As far as the lake itself is concerned the main object would be to overcome the vagaries of level which have been a major impediment to the development of transport facilities, fisheries and all types of lake-shore enterprise. For example, stabilisation would greatly facilitate the improvement of ports on the lake and the irrigation of a considerable area of land on the southern shore of the lake.

On the Shire river the production of hydro-electric power may prove the most important part of the project so far as Nyasaland is concerned. There appears to be no reason why very considerable supplies of hydro-electric power should not be obtained at reasonable cost by the use of the Middle Shire, and such power would be of great value to the Southern Province of Nyasaland, both for industrial development and the improvement of public utilities and also for use in land irrigation. This power might also be used in the adjoining area of Mozambique.

The other main purpose of the scheme would be the irrigation of large areas of potentially productive land in the Lower Shire valley and the reclamation of land at present virtually useless owing to flooding. In Nyasaland such irrigation and reclamation might extend to more than 400,000 acres, and it is also likely that river control would bring very substantial benefits to that part of Mozambique lying on the east bank of the Shire river, adjoining and below the southern tip of Nyasaland.

It will thus be seen that the Shire Valley project is one of great importance to Nyasaland and is calculated to be of substantial benefit to neighbouring territories of Tanganyika and Portuguese East Africa, with whom the Government of Nyasaland will consult. It is in effect a comprehensive scheme for the development of the resources of lake Nyasa and the Shire river for the common benefit of the territories having an interest in them.

Fig. 1. Progress of construction when war broke out in 1939

Hydro-electric Development in Uruguay

By KENNETH E. SORENSEN (Harza Engineering Company, Chicago). Details are given of the Rincon del Bonete station on the Negro River, and other projects and potentialities are considered.

THE Republic of Uruguay with 2,300,000 inhabitants and an area of 72,172 square miles has, at the present time, a generating capacity of 225,000 kW. Of this, 200,000 kW is included in the system serving Montevideo, the capital of the republic. Before 1946 all generation was thermal, and as Uruguay is devoid of fuel resources the country was dependent on imported oil or coal for power. World War II, with its attendant shortages and rationing of fuel, severely curtailed operation of these thermal plants and indeed necessitated the burning of grain as a substitute to maintain even minimum levels of generation. The construction of the Rincon del Bonete hydro-electric plant, which was begun in 1937, was greatly hampered by the shortages of equipment during the war and the first unit of this station was not put into operation until December, 1945.

The major watercourse within the borders of Uruguay is the Rio Negro, having headwaters at the Brazilian border and flowing in a general southwesterly direction to join the great Rio Uruguay on the Argentine border some 40 miles above the La Plata estuary. The drainage area of the Rio Negro is 26,600 square miles, or about 37 per cent. of the total area of the country.

To the south, closer to Montevideo, but of lesser size, are the rivers Rio Cebollati and Rio Santa Lucia. To the north are several major tributaries of the Rio Uruguay such as the Rio Queguay, Rio Bayman and the Rio Arapey. These all take a part in the plans which have been formulated for the hydro-electric development of the country.

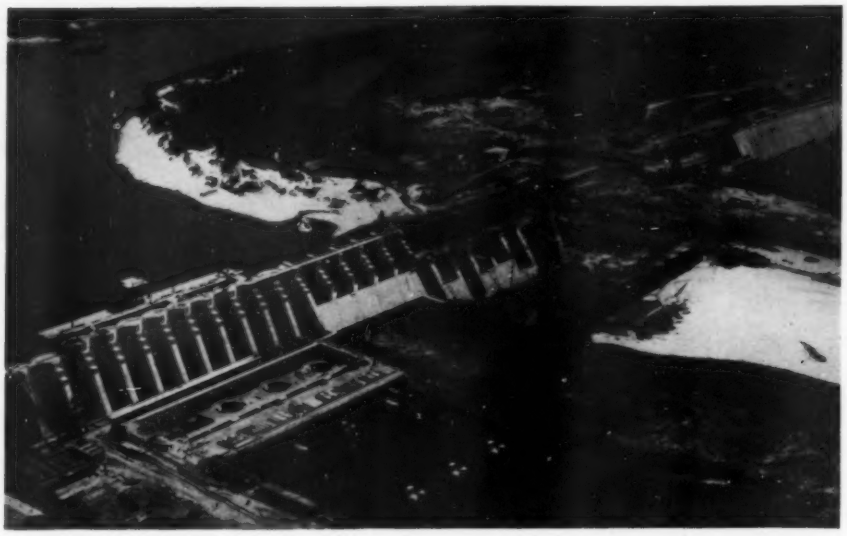


Fig. 2. Progress of construction in May 1942 when RIONE assumed responsibility for the completion of the work

Fig. 3. Map of Uruguay showing Rincon del Bonete reservoir and transmission line to Montevideo

The Rio Uruguay, which forms the international frontier with Argentina and has a drainage area of 119,000 square miles, is, of course, one of the major rivers of the world.

History of the Rio Negro studies

The Rio Negro has been the subject of intensive engineering study for the past 50 years. Prominent among the names of those who have devoted much of their lives to the development of Uruguay is that of Victor B. Sudriers. Recently Director of Hydro-Electric Studies for the nation, Sudriers, in 1904, then a young army engineer officer, first initiated scientific investigation of the Rio Negro. Navigation was the primary objective at that time, but, by 1911, the hydrographic studies were extended to include consideration of hydro-electric potentialities. During the succeeding years, detailed investigation was made of various sites both by local and foreign engineers. In 1912, the J. G. White Co. presented plans for a 40,000 kVA plant at the site known as Picada de los Ladrones. Opposition by the director of the Montevideo system blocked the execution of this plan despite the most active support of Sudriers, then Minister of Public Works, and other prominent engineers. Other plans were proposed including one for diversion of water from the Rio Negro through a canal to Montevideo, thus providing for navigation, irrigation, power, and water supply, but not one was to reach realisation until some 20 years had passed.

In June of 1930, Dr. Adolfo Ludin approached the government with plans for the construction of a plant on the Rio Negro at the site Rincon del Bonete. This plan became the subject of much discussion and heated debate among the engineering fraternity. After several years of investigation and some modification, the plan was accepted in definite form by the government in 1934.

Rincon del Bonete plant

Funds were raised through the issue of public bonds and contracts were advertised. On April 15, 1937, a contract was signed with a German syndicate which included the firms of J. M. Voith, Siemens Schukert Werke, and AEG of Germany and Siemens Bauunion and Compania General de Obras Publicas of Buenos Aires. The first of these firms was to furnish and install all machinery and hydraulic elements, the next two firms all electrical equipment, and the last two were to construct all civil-engineering works.

On this basis work commenced and proceeded normally until September 1, 1939. By this time work was progressing on the power house and the portion of the dam within the right bank cofferdam (Fig. 1). The German syndicate continued work until May 7,

Fig. 4. View of the completed dam and power station showing spillway discharging at 2,000 cu. m. per sec.

Fig. 5. Typical sections of dam and spillway

1942, when Uruguay broke relations with Germany, but this period had been one of increasing obstacles to construction and most of the machinery, being fabricated in Germany, never reached Uruguay.

At the time of revocation of the contract most of the dam had been completed (Fig. 2). The powerhouse substructure was about complete with intake gates, scroll cases, draught tubes, stop logs, intake and draught tube cranes, and trash rake all installed. Of the turbines and generators, only the speed rings and generator supports were in place for one unit, no moving parts having been installed. Part of the superstructure and certain auxiliary buildings were completed. No work had been started on the transmission lines nor on the receiving substations in Montevideo.

Negotiations were initiated in July of 1941 with the government of the United States of America which resulted in the granting of an Export-Import Bank loan, together with the required licences to enable the purchase in the United States of the remaining equipment and supplies necessary for completion of the project. The Harza Engineering Company of Chicago were retained for completion of designs and for the adaptations necessitated through use of North American equipment to fit embedded parts. Construction was continued by the Uruguayan government's own forces to successful completion, the first unit being placed in service on December 21, 1945.

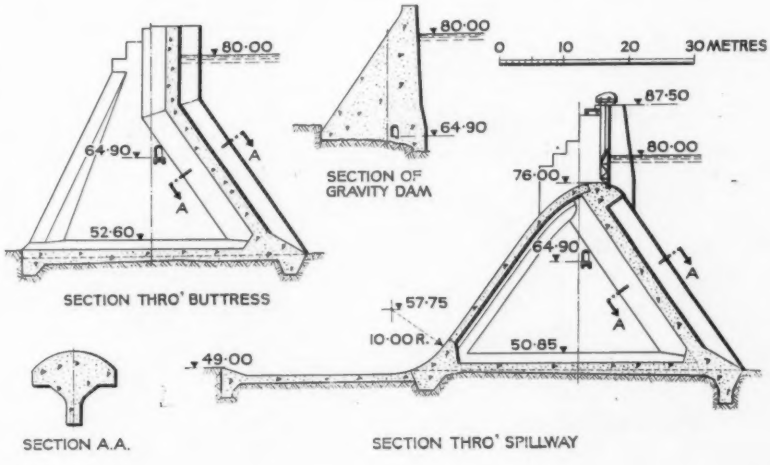
General description

The Rio Negro above the Rincon del Bonete plant has a watershed area of 14,600 square miles over which the mean annual rainfall is in the order of 1150 mm (45 in.) providing a mean flow of about 515 cu. m. per sec. (18,100 cusecs) with minimum of 10 cu. m. per sec. and maximum of 5,500 cu. m. per sec. as determined from 38 years of record. Annual rainfall is subject to considerable variation ranging from 700 mm to 1,900 mm.

The reservoir, at normal pool elevation of 80·00 m. above sea level, embraces 1,140 sq. km. (440 square miles) and contains 6·4 cu. km (5,180,000 acre-feet) of useful storage above minimum drawdown level at an elevation of 71·50 metres. Of this volume 0·7 cu. km is reserved to assure peaking capacity during critical dry periods. To permit topping of extreme floods from a possible 9,000 cu. m. per sec. inflow to 5,000 cu. m. per sec. outflow, an additional volume of 4 cu. km is available between elevations 83 and 80 metres. It is proposed to raise the operating level to 83 metres, which will yield an operating head of 32 m. (105 ft.). Very nearly complete regulation of the river is possible with the volume of storage available in the reservoir.

Dam and spillway

The major portion of the dam is of the round-



head buttress type flanked by gravity concrete wings. The maximum height from crest to the deepest excavation is 40·80 m. (134 ft.). Provision has been made for raising the crest by an additional 2·60 m. (8·5 ft.) in the future. Fig. 5 shows the typical sections of the dam and spillway. The roundheads and the buttresses are unreinforced except nominally at the junction of head and buttress and of buttress and base slab. Both the spillway slab and base slab are, however, heavily reinforced. The spillway, consisting of 12 bays of 10·5 m. each, is designed to pass 4,900 cu. m. per sec. (173,000 cusecs) with pool elevation of 83·00 m. Each bay is provided with vertical wheeled gates, five m. high, operated by individual electrically driven hoists.

Foundation pressures under the buttress dam are less than 4 kg. per sq. cm. (56·8 lb. per sq. m.) or about half that of a comparable gravity dam. Foundation conditions were such that the lighter pressures were desirable, and as materials for a rock or earth-fill dam were not readily available the buttress type was selected for the higher portions of the dam.

An extensive grouting programme was found necessary to consolidate portions of the foundation, and, more important, to reduce the seepage through the strata under the dam. This was accomplished with a double curtain of grout under the upstream cut-off trench, grout being injected through holes spaced approximately 4 m. along each curtain, the curtains being 1·80 m. apart. The holes were in general 25 to 30 m. deep and extended into the underlying impervious rock. Grouting was effected in approximately 4 m. stages proceeding from top to bottom, at pressures varying from 3 to 25 atmospheres. Both cement and chemical grouts were used, the latter consisting of successive injections of sodium silicate and calcium chloride in volumetric ratio of 3 to 2. The results were highly successful with permeability of some aquafers reduced from 22 to 3 litres per metre per second.

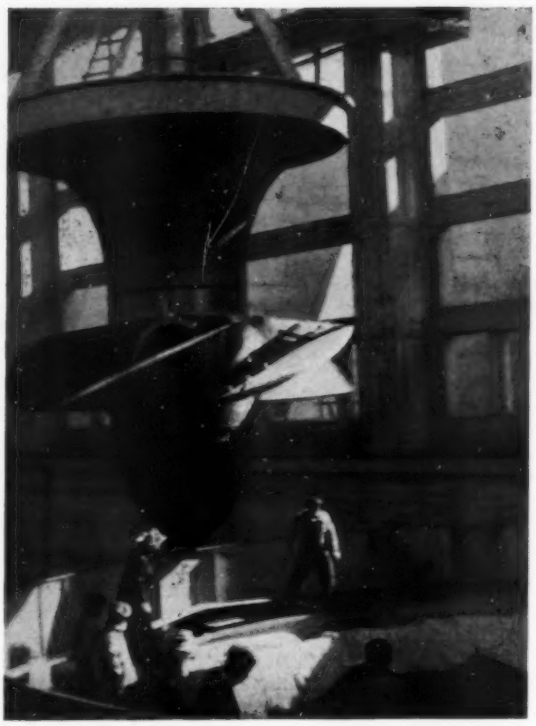


Fig. 7. One of the four 6-bladed Kaplan rotors ready for positioning

Intake and power house

As shown in Fig. 6, the intake, integral with the dam, controls the entrance of water to short steel penstocks. Individual wheeled service gates are provided, remote controlled, with a 60-sec. closure time. Slots are provided for emergency closure by use of

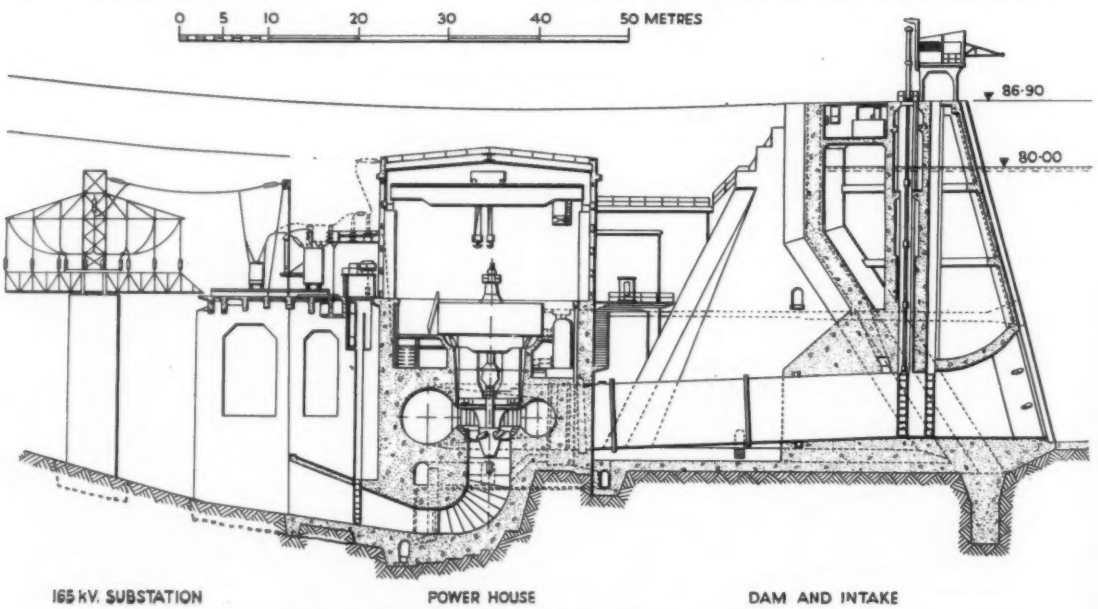


Fig. 6. Section through dam and power station

Fig. 8. Rotor of one of the 13,800 V, 32,000 kVA generators

Fig. 9. Interior view of Rincon del Bonete power station

a spare gate lowered by the intake gantry crane, which also handles the trash-raking facilities. A short, 7 m. diameter, steel penstock connects each intake with the turbine scroll case.

The four turbines are six-bladed, variable-pitch Kaplan propeller units, the embedded parts being manufactured by J. M. Voith Co. (Fig. 7) and all other parts by S. Morgan Smith Company. The oil-servomotor-operated wicket gates are of cast steel, clad in stainless steel at points subject to cavitation, as are the turbine propeller blades. The turbines are rated at 40,000 h.p. at 21·1 m. head, 125 r.p.m., and have a maximum output of 45,000 h.p. They are designed to withstand a runaway speed of 325 r.p.m.

The generators, four in number, manufactured by General Electric Company are rated at 32,000 kVA 0·95 power factor, 13·8 kV, 1,340 amperes, 50 cycle, 125 r.p.m. They are of the umbrella type and on each generator is mounted its own main exciter and pilot exciter, together with the permanent-magnet generator and oil head. (Figs. 8 and 9). Two 130 ton travelling cranes provide handling and erecting facilities within the power house.

Draught tube unwatering is made possible with use of steel stop-log sections handled by crane from the draught-tube deck. On this same deck are mounted the main transformers. Each generator connects to three single-phase transformers, water cooled, 13·8 kV/165 kV between phases, 32,000 kVA capacity. Lightning arresters are mounted directly on the transformers. Immediately downstream from the transformers and founded in the tailrace are concrete piers which support the circuit breakers and switchyard structures. Station service power is provided by a three-phase, 380 V circuit obtained from two banks of single-phase 13·8 kV/380 V transformers.

Marine railway

To permit passage of ships into the reservoir from downstream waters, a marine railway was constructed

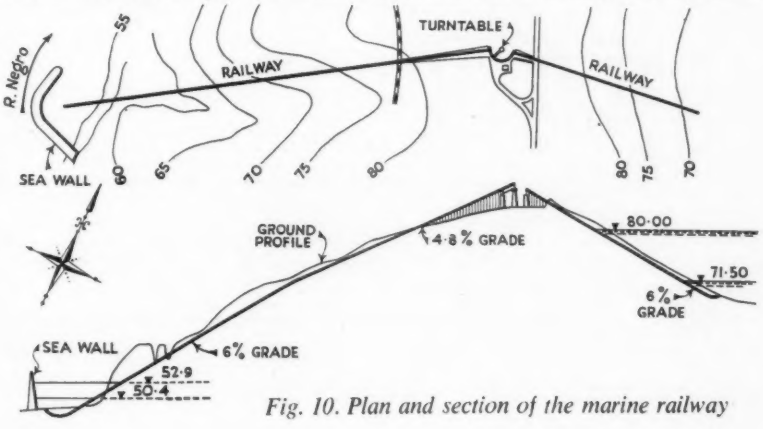


Fig. 10. Plan and section of the marine railway

capable of handling boats up to 110 tons gross weight. As shown in Fig. 10, this railway consisted of two 6 per cent. inclines with a turntable at the crest.

Transmission system

The Rincon del Bonete hydro-electric plant is connected with the Montevideo system by two 161 kV, three-phase parallel circuits, 232 km. long. The two lines are carried on separate towers, 100 m. apart until within 20 km. from Montevideo from which point area restrictions required the mounting of the two circuits on common towers. The conductors used are hollow segmented copper, 21 mm. external diameter, with 150 sq. mm. copper area. Resistance at 20°C. and at 50 cycles is 0·1186 ohm. Low ground resistance made earthing simple, and only at isolated points were counterpoises necessary. Two shield wires are carried on both the one-circuit and two-circuit towers. The towers are of galvanised structural steel with concrete foundations, with an average spacing of towers of 300 m. The design is shown in Fig. 11.

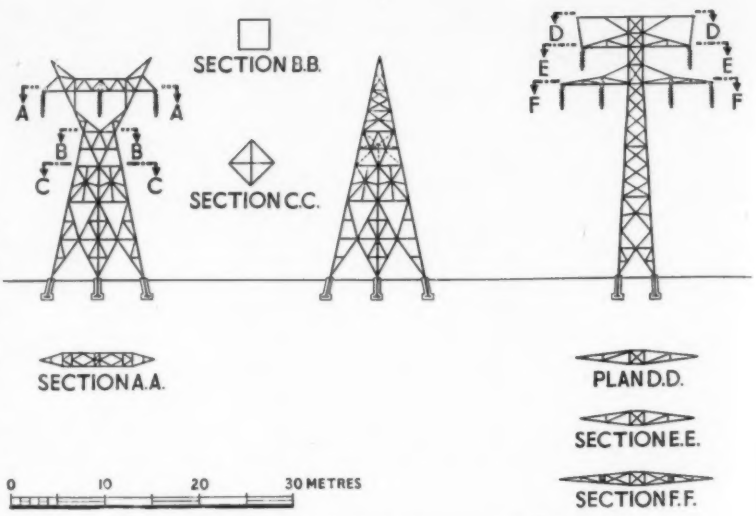


Fig. 11. Design of transmission towers for 161 kV line

Power system

The first electric lighting system was installed in Montevideo in 1887. Today the capital city has 80,000 kW of steam generating capacity in addition to the

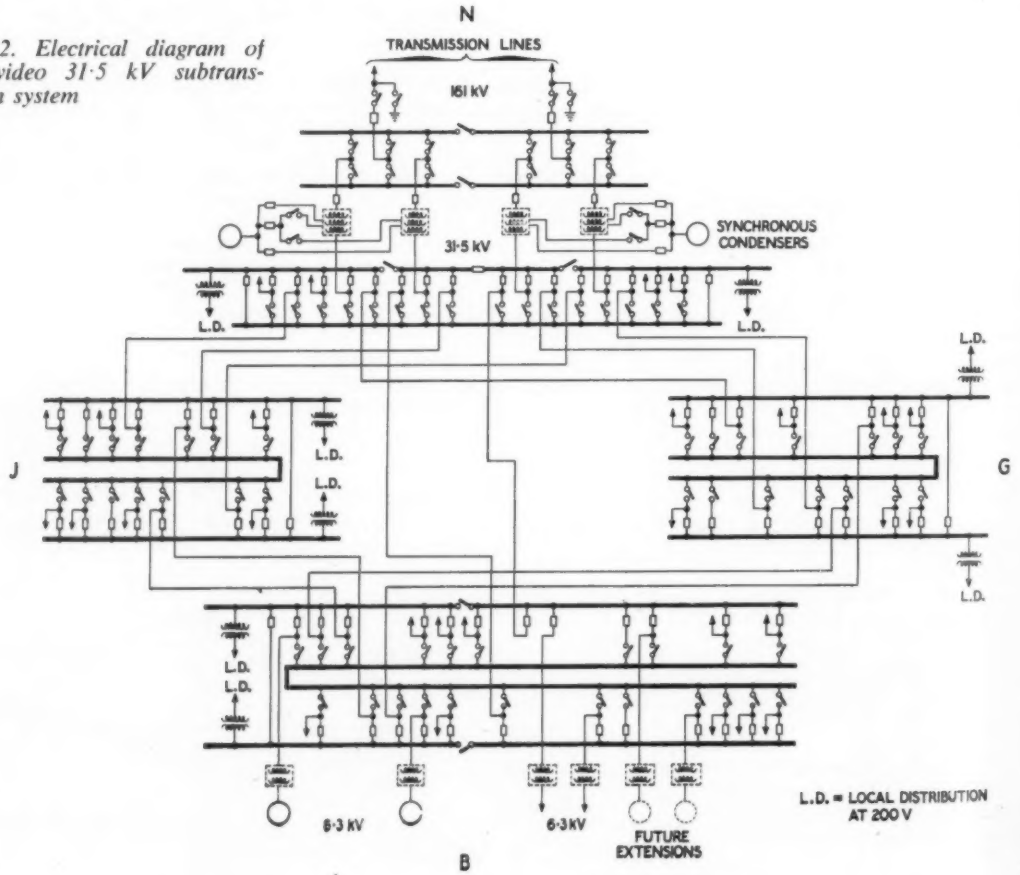


Fig. 12. Electrical diagram of Montevideo 31·5 kV subtransmission system

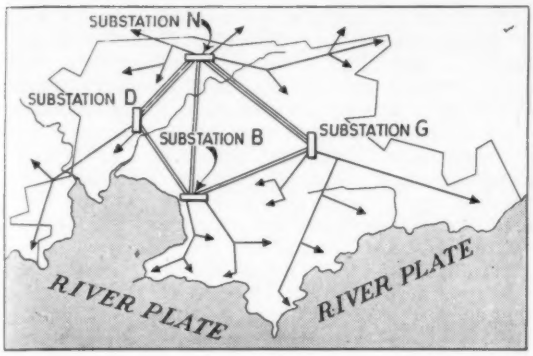


Fig. 13. Diagram of Montevideo 31·5 kV subtransmission quadrangle

power received from the Rincon del Bonete hydroelectric plant. Not connected with the Montevideo system, but serving smaller outlying communities are some 140 diesel-powered generating stations aggregating 24,000 kW in sizes ranging from 30 kW to 3,300 kW. In 1896 the then existing private utilities were transferred to the government, which from that time forward has owned, operated, and expanded its generating and distribution facilities. The purchase by the government in 1931 of all telephonic networks within the country resulted in the formation of the combined agency "Administracion General de Las Usinas Electricas y los Telefonos del Estado" (U.T.E.) which continues today as the administrating and operating agency for the nation's power and telephonic systems. For the specific purpose of construction of the Rincon del Bonete plant and future plants on the Rio Negro, a separate agency was created entitled "Comision Tecnica y Financiera de las Obras Hidroelectricas del Rio Negro," commonly called RIONE.

The thermal capacity of the present power system is vested in two stations. The somewhat antiquated Calcagno station has two 10,000 kW and two 5,000 kW generators and one additional 10,000 kW generator now being used as a synchronous condenser. The more modern Batlle station has two 25,000 kW generators.

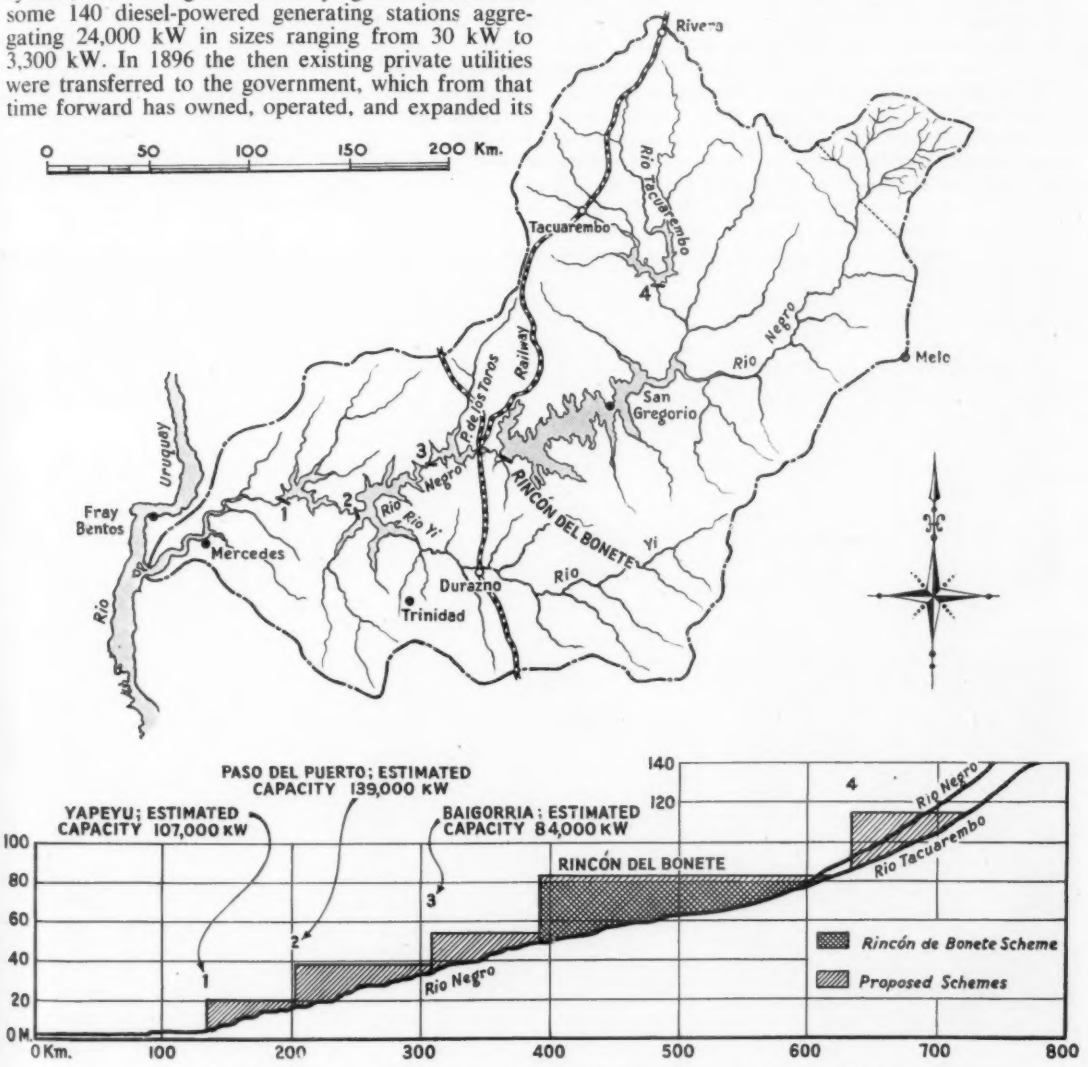


Fig. 14. Map and profile diagram showing the development plan for Rio Negro

The subtransmission system of Montevideo is 31·5 kV and forms a quadrangle encircling the city with substations at each corner, as shown in Figs. 12 and 13. Power from the Rincon del Bonete plant enters the quadrangle through the transformers at substation N which also houses two 20,000 kVA synchronous condensers. Supervisory control for all four substations is centred at the Batlle steam station adjoining substation B. Municipal distribution is through 6·3 kV feeders with low-tension distribution at 220 V.

Hydro-electric development plans

Study and exploration continue under the guidance of the national department of hydro-electric studies and RIONE with the view towards increased development of Uruguay's water-power resources. Several other plants are being considered on the Rio Negro at Baigorria, Paso del Puerto and Yapeyu as well as on its major tributary, the Tacuarembo. Fig. 14 shows the profile of the Rio Negro and the estimated capacities of three projected downstream plants.

At intervals over the past 60 years, plans and studies have been made to utilise the waters of the great Rio Uruguay, the site at the rapids of Salto Grande being favoured by most investigators. This site is located near the city of Salto, about 385 km. straight-line distance from Buenos Aires, and 216 km. from the Rincon del Bonete plant. Such a project, of course, would be international in character, and plans have been presented on several occasions both by Uruguay and by Argentina. On December 30, 1946, a treaty was signed and a joint Uruguay-Argentine commission was formed to carry on technical studies of the project until ratification of the treaty by the respective national assemblies should enable full-scale developments. To date ratification has not been forthcoming.

Among the more notable plans presented for the development at Salto Grande are those of Mollard in 1912, Cardiel in 1918, Gamberale and Mermoz in 1928, Ludin in 1930, and Forti in 1941. Ludin, in a review based mainly on the work of Gamberale and Mermoz, considered a two-stage development with initial installed capacity of 250,000 kW and ultimate of 500,000 kW under a normal head of approximately 14 m. Gross annual generation for the two stages was estimated at 1,780,000,000 kWh and 2,850,000,000 kWh respectively. Spillway capacity of 27,000 cu. m. per sec. was deemed necessary. The plan by Forti proposed a greater installed capacity of 875,000 kW at average head of 21 m.

Installations of lesser magnitude under present consideration are on the Rio Queguay (15,000 kW), Rio Cebollati (11,000 kW) and the Arroyo Cunapiru (10,000 kW). These plants would furnish power to areas not now served by the Montevideo system.

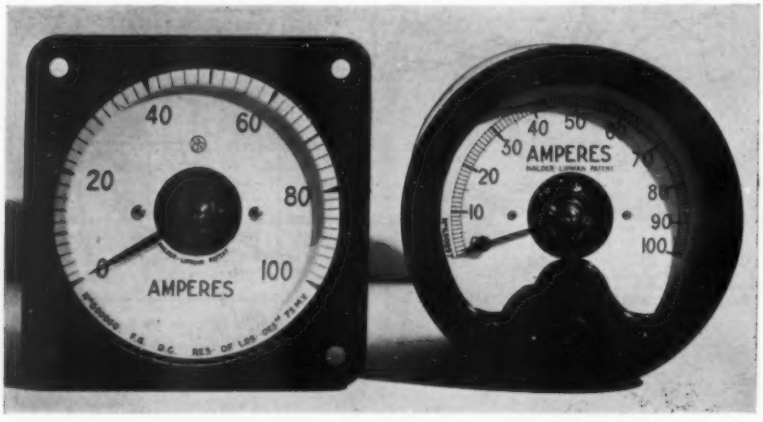
First suggested by Ludin in 1930 and subsequently developed more fully by Sudriers, is the feasibility of a pumped-storage plant on the shores of the La Plata at Montevideo. As proposed, a storage reservoir would be established on a hill near the shore providing a gross head of 117·5 m. with 450,000 cu. m. capacity as an initial stage and gross head of 127 m. with 800,000 cu. m. capacity in ultimate installation. Generator capacities for these stages would be 25,000 kW and 50,000 kW respectively. With turbines designed to be used as pumps as well, surplus power available from other plants during off-peak hours could be used to pump water into the reservoir from the La Plata, which then could be used to drive the turbines during peak-demand periods.

Needless to say, with all of the above-mentioned plans for hydro-electric development, the value of supplementary thermal capacity has been considered and co-ordinated with the installations proposed.

Land and water are the prime resources of the Republic of Uruguay, and in the construction of the Rincon del Bonete plant the first great and significant step has been taken in putting to useful service the nation's wealth of potential water power.

Instruments with Shadow Elimination

A range of control-board instruments incorporating a new method of scale indication has been introduced recently by Nalder Brothers & Thompson Limited, of London, E.8. These instruments are designed to facilitate readings by eliminating the side shadow common to conventional instruments; they are fitted with domed or extended glass fronts, their dials are in the same plane as the front of the mounting flanges, and their scales are of the "platform" type so that the pointers traverse the dials in the same plane as the scale markings, thus avoiding parallax error. A comparison of the side-shadow effects with the new and the old types of ammeter is shown in the accompanying illustration, the new model being the one on the left.



Shadowless instrument (on left) compared with normal instrument

Holman Drifters. General Catalogue, Section E.2, received from Holman Bros. Ltd. of Camborne gives technical particulars and illustrates the various drifter rock drills they manufacture. The range is extensive and extends from light-duty machines such as the S.L.200 to the S.L.16A which is designed for the heaviest duties.

Fabrication of Water Mains

By P. L. POCOCK

Some account is given of the manufacture of fabricated water mains and of the care that is necessary for the welded jointing to give trouble-free service.

HIGH standards of workmanship are particularly necessary for the production of fabricated water mains. After manufacture, the pipes or assemblies are either bitumen or concrete lined, and it would consequently be very costly if faults were discovered after the pipes had been coated, as the lining would have to be removed before the defect could be rectified. Therefore, each production operation must be closely controlled, checked and inspected.

To ensure that standards of quality are maintained, codes of workmanship, inspection and fabrication practice have been instituted by such bodies as The British Standards Institution, The American Water Works Association, The American Petroleum Institute, and various codes have also been sponsored by The American Society of Mechanical Engineers. It will be appreciated that the standards laid down and contained in these specifications and codes are of an exacting nature and rigid control is necessary during fabrication if they are to be maintained.

The majority of specifications demand that when plates are cut to size, all edges must be uniform, smooth and free from scale and slag accumulations, and that the edges to be welded, if prepared by flame cutting, shall be approved by the inspector before any welding is undertaken; the resulting edges for welding must also be uniform throughout the entire length of the joint.

Before the rolling of longitudinal edges all plates should be lap broken by a continuous rolling operation or by a press having dies that are machined to the proper radius of the pipe shell, and the pressure exerted in the lap-breaking operation shall be sufficient to secure a true and uniform curve at the edges of

Fig. 1. Fabricated water mains and lobster-back bends for circulating-water installations

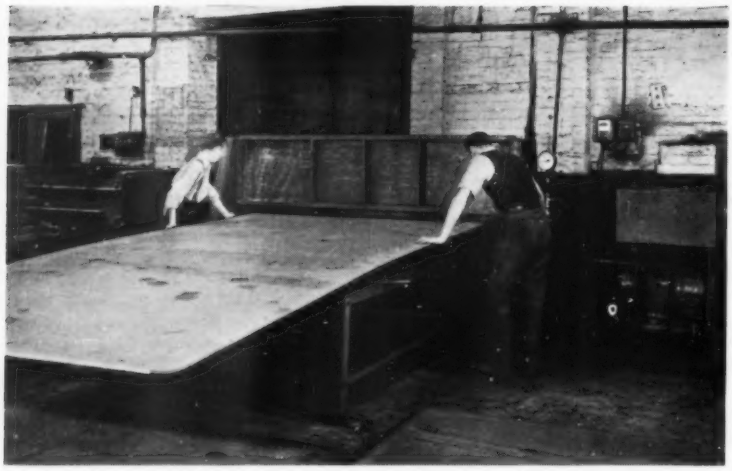


Fig. 2. Lap-breaking press

the plate. Plates should then be rolled to the diameters desired. It is clearly stated in the specification covering this work that plates so rolled as to require hammering in order to form the plate into the desired shape shall not be accepted.

It is also a requirement that all edges and surfaces of the plates adjacent to the edges to be welded should be cleaned of oil, grease and rust down to bright metal, and apart from this, to conform to the specification for welding, the plates must be accurately matched and retained in position during the welding operation. Tack welds can be used to hold the edges in line provided the thickness permits this preliminary weld to become thoroughly fused and to become incorporated in the weld during the welding operation. Whatever the method employed, it must result in the finished pipe forming a circular cross section throughout its whole length.

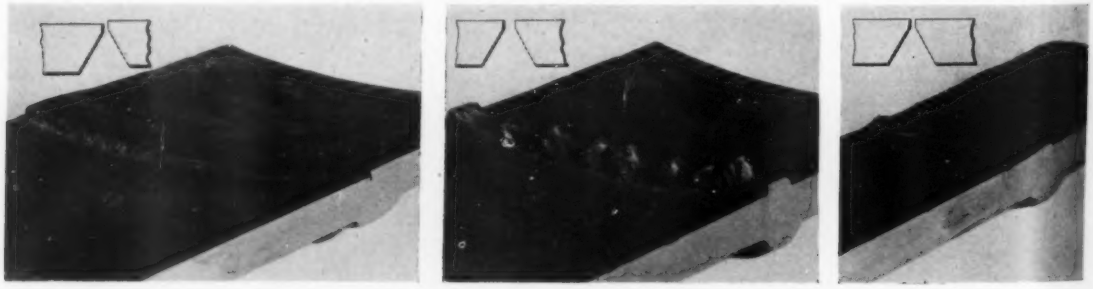
One of the major factors affecting quality and workmanship of welds is the method adopted for preparing the plate. Of all the operations which are necessary to produce fabricated pipework, the process of welding is one which relies mostly on the human element, and the operator must be vigilant and truly interested in his work. A bad weld can be very troublesome and costly, and to prevent anything of the sort happening it is necessary to provide the operatives with well prepared joints to simplify the work as much as possible. The necessity for a high standard of plate preparation will be appreciated if the difficulty of welding a small diameter pipe is visualised, as it is impossible to weld the inside and all welding has to be carried out from the outside of the pipe using a chamfered joint to facilitate adequate penetration at the root.

The results of misalignment of the root faces can be clearly seen in Fig. 3. Fig. 3a illustrates the defective joint obtained when the abutting root faces are not lined up correctly —a fault which leads to inadequate and uneven penetration. Fig. 3b shows the excessive penetration caused by the root gap being too wide, while Fig. 3c indicates the even and uniform penetration obtained when the preparation and line-up for welding are correct. The essential requirements to maintain a high standard of workmanship are:—

A. Adequate process planning.
B. Simplification of each production operation.
C. Inspection check points to ensure that the specifications are being fully observed.
D. Plant and equipment to carry out each operation efficiently.

It is essential that each deposited layer of weld metal should be thoroughly cleaned before additional weld metal is applied to its surface and that the finished bead be central to the seam; also the finished joint must be free from depressions, undercut edges, burrs, irregularities and valleys.

When automatic welding is used in the fabrication of water mains and the automatic machine does not obtain a fusion weld that will penetrate to the inside of the pipe and protrude beyond the contour of the inside plate surface, a weld must be deposited in the root of the groove on the inside of the pipe; in this case chipping back to sound weld metal, in the root of the groove, is necessary before the automatic weld



a *b* *c*

Fig. 3. (a) Effect of incorrect alignment; (b) excessive penetration; (c) correct preparation and alignment

is deposited.

If the welding is stopped for any reason, special care should be taken when it is resumed in order to obtain complete penetration between the weld metal, the plate and the weld metal previously deposited, and if the submerged arc process is used, flux must be redistributed before the work is resumed. To allow for internal and external lining or coating the various codes require the height of the outside weld bead above the contour of the plate surface to be not more than $\frac{1}{8}$ in. Heights exceeding this limit must be removed by grinding or chipping. All longitudinal spiral and girth welds on the inside of the pipe must be ground or chipped down if necessary so that the height of the weld bead shall not be more than $\frac{1}{16}$ in. above the contour of the plate surface. Grinding or chipping of the weld bead below surface of plate is not permitted under any circumstances. Experience in this class of work shows that the most economical method of complying with the specification relating to the height of the welding bead is to adopt the preparation illustrated in Fig. 4, the resulting joint being shown in Fig. 5 from which the neat and flat finish will be observed.

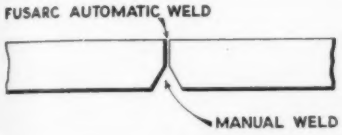


Fig. 4. Preparation for Fusarc and for manual welding

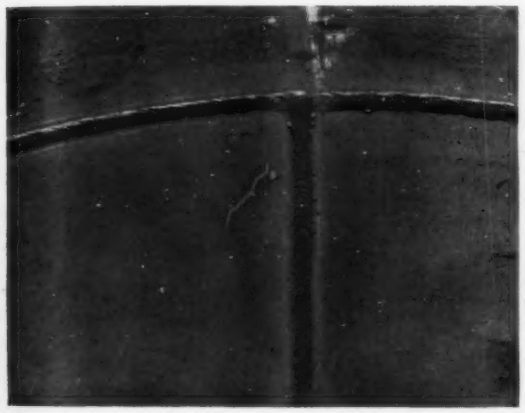


Fig. 5. Finish obtained with Fusarc welding

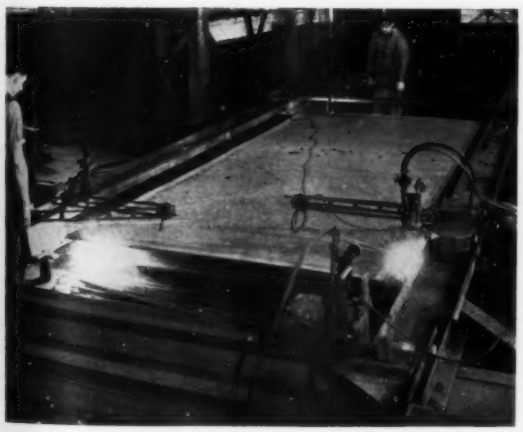


Fig. 6. Oxy-acetylene machine for cutting and bevelling plate edges

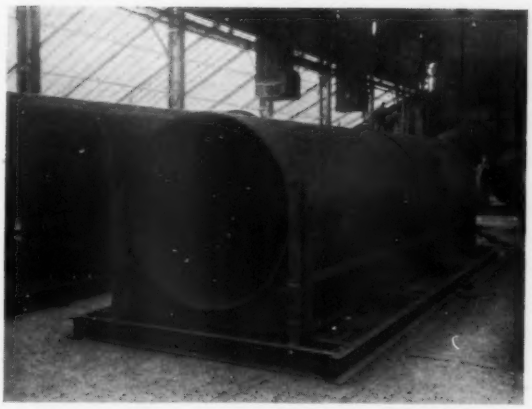


Fig. 7. Jig for assembling a length of pipe

Production is controlled by the efficient planning of each operation, and schedules are issued to the works giving sizes of plate, methods of preparation and full details of the methods of forming an assembly. A planned welding schedule is also issued, giving details of the type of joints, electrodes, amperage and full information on the technique to be employed and the methods to be adopted to prevent distortion. To ensure accuracy in cutting the plates to size, jig shearing is employed together with flame profiling machines using floating cutting heads. A machine designed to cut plates to size and simultaneously bevel the edges is shown in Fig. 6. To simplify assembly operations, jigs are used to ensure perfect line-up of the sections forming the required length of pipe. Such a jig is shown in Fig. 7. The pipe sections are placed in the cradle portion and after rough lining up, a half circular arm is brought over each joint, pressure being applied by a toggle action when this arm is clamped in position. This automatically positions the pipe in the cradle and as the arms apply the pressure on three equally spaced points around the circumference of the pipes, the joint is automatically lined up. All that is now required is that the operator should rectify any local misalignment. The sections are then tacked together.

As the quality of welding can and does vary due to the temperament and the varying efficiency of the operators, it is necessary to overcome this wherever possible by the use of manipulators and jigs which are designed to position the weld seam in the gravity or "downhand" position. A typical example of this is the manipulator shown in Fig. 8, for welding flanges on pipes. This can be positioned between 35° and 55°, enabling the inside and outside fillet welds forming the flange to be positioned at 45°.

The pipe is then rotated at a set speed and the welding carried out with an electrode of suitable size, as specified on the schedule. This same principle has been adopted with all manipulators and since the work is rotated, in the downhand position, under the operator's arc, neatness of contour and welding is achieved.

Fig. 8. Manipulators for welding flanges, etc.

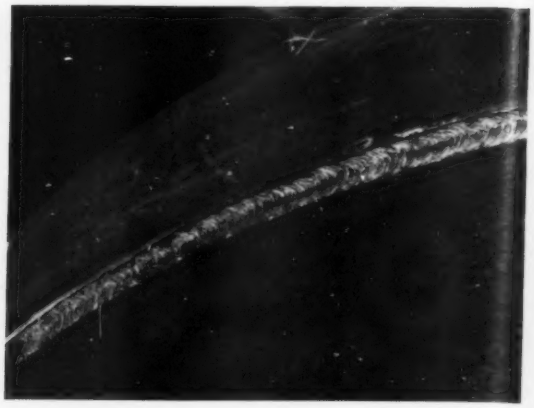


Fig. 9. Finish obtainable by the use of manipulators

All the operator has to do is to stand and hold the electrode keeping the required arc length. The installation of these manipulators has increased production, reduced handling and improved the quality of the welding.

The improved finish and contour of the welded seams deposited by the aid of manipulators can be seen by reference to Fig. 9, which shows a fillet weld deposited at 45° in the manipulator.

Fig. 10 shows how the work flows smoothly through a well arranged shop, entering one end as raw material and leaving the other end as the finished pipe. As the work passes through it is checked and inspected before cutting to size, after rolling, and then again after assembly, before welding, for preparation for welding and accuracy of the assembly of the plate edges. The press and bending rolls are fed by a conveyor and Mono rail system, this having the effect of reducing both the waiting and handling time, as the labourers who load the conveyors serving each machine can move the material forward at the same time that the machine operators are employed in processing the plate; consequently as soon as one cycle of operation is complete a further plate is ready for processing.

When the internal seams have been welded, the internal welds are checked, and when passed, the work proceeds to the " Fusarc " automatic welder for the external welding. This machine can be seen in the foreground of Fig. 8.

Welding is checked at all points by radiographic spot checks and by the taking of trepanned plug samples from welds. After final cleaning operations

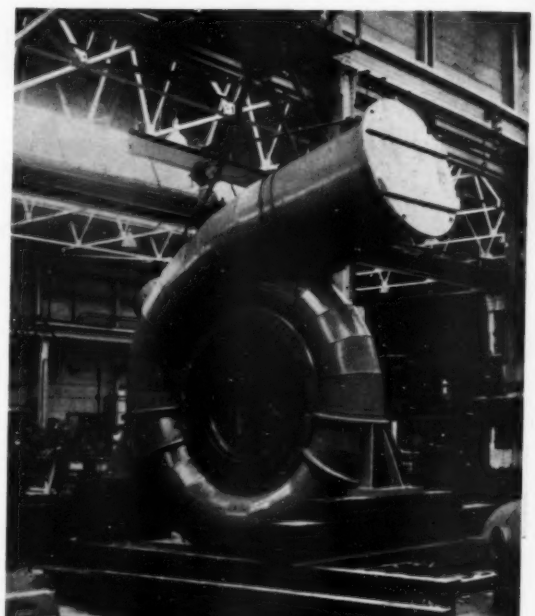


Fig. 11. A turbine casing fabricated entirely by welding

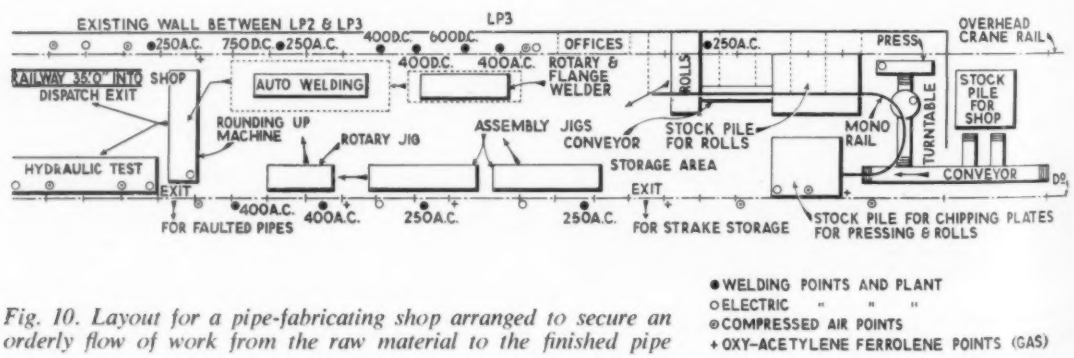


Fig. 10. Layout for a pipe-fabricating shop arranged to secure an orderly flow of work from the raw material to the finished pipe

Fig. 12. Welding pipe lengths together on site

on completion of the external welding, the pipe is rounded up at each end to fit into spigot joints or Johnson couplings and is then hydraulically tested.

The development and marking off of segments for fabricated turbine casings calls for a very high standard of ability and workmanship. Fig. 11 indicates how the finished job amply repays the skill and attention put into it during manufacture. Although many of the connections between pipe lengths are made by flanges, spigot joints or patent couplings, quite a large proportion are coupled together by side weldings and this should preferably be done by the firm supplying the pipes. Several lengths of pipe in the course of welding and laying are shown in Fig. 12 and since in most instances site welding has to be carried out in position, a high degree of skill is necessary to ensure adequate and even penetration at the root face on the inside of the pipe. Furthermore, when pipes have to be welded on the site, the bitumen lining is not carried right to the end of the pipes, but is kept back approximately 4 in. so that an area on each side of the joint is left bare for welding. After the welding is completed and the pipes are laid, this area is coated on site by the aid of a mould which fits around the pipe and into which the liquid bitumen is poured.

In conclusion, the benefits obtained by a close and efficient control of operations, adequate supervising and inspection staff, together with the use of modern plant and methods of handling and manipulation for welding can be readily seen by the quality of workmanship illustrated in Fig. 13. This shows a close-up view of a fabricated pipe from which a trepanned plug has been taken from the weld. The upper portion of this figure shows the radiographic interpretation of part of one of the circumferential welds.

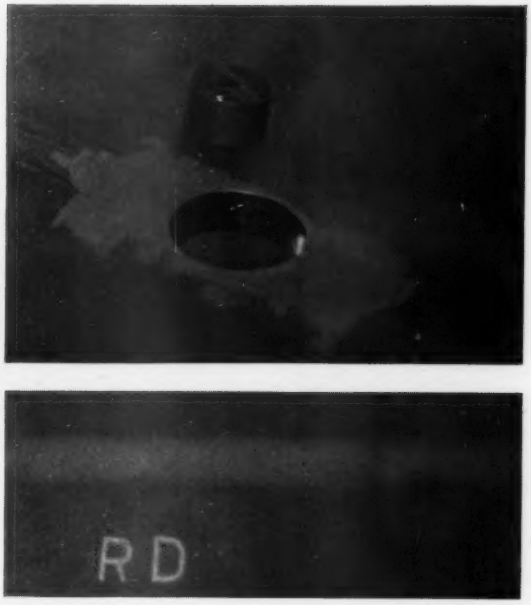


Fig. 13. Specimens showing quality of welding

The author would like to express his appreciation to the directors of Redheugh Iron and Steel Co. (1936) Ltd., for the help afforded him in compiling this article and for permission to publish the foregoing information and photographs.

Correspondence

Harnessing African Waters

To the Editor of WATER POWER

I have read with great interest the article in your September number: "Harnessing African Waters." It so happened that in 1915 I had some correspondence with Sir H. H. Johnston on the question of the utilisation of the water power of the River Shire, and proposed that investigations in the form of surveys and records of the annual flow of water should be started, as it would take years of observation to get sufficient data to plan any scheme that might mature in years to come.

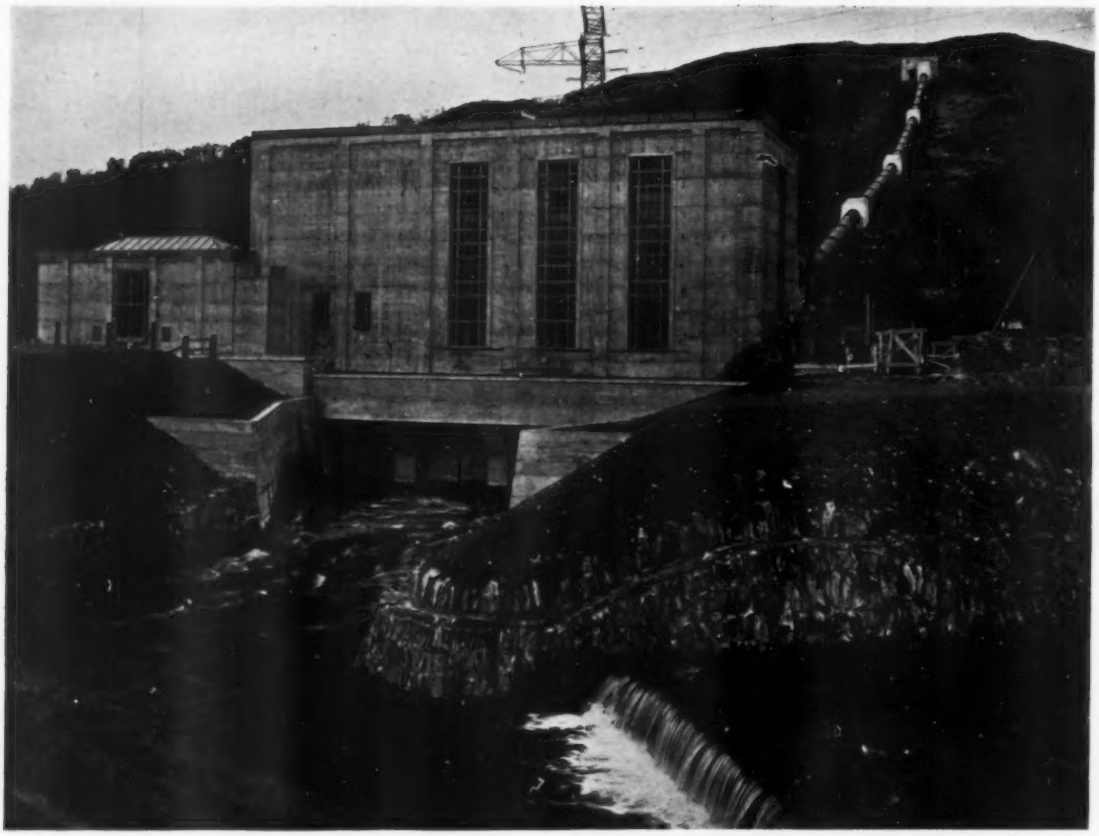
In a letter to me dated August 4, 1915, he states: ". . . I have thought it best to send a copy of your letter to the Colonial Office . . ." so it may be that for some 36 years a letter about the development of the Shire River has been pigeonholed in the C.O.

However, the war lasted for another three years and during the following depression interest faded away.

Apart from six years in the Natal Government Railways I have been building and managing water-power plants since 1898, hence my interest in these things.

I have now joined the great army of the "Ex"-es but hope to live long enough to get to know some data regarding the preliminary surveys in connection with Lake Nyasa and the Shire.

SIGURD BRINCH, C.E.,
Norway. INGENIOR M.N.I.F.



A view of Grudie Bridge generating station and pipeline taken from the tailrace

Grudie Bridge Generating Station

The Grudie Bridge generating station, which was brought into commission last winter, represents the first stage in the development of the Conon Valley in Ross-shire, which will be one of the biggest schemes for which the North of Scotland Hydro-Electric Board is responsible. In this article the mechanical and electrical features of the station are described.

GRUDIE Bridge power station is the first of six generating stations which the North of Scotland Hydro-Electric Board proposes to build to develop the resources of the Conon Valley in Ross-Shire. The ultimate installed capacity of the scheme is expected to be 107,000 kW, and the development is one of the largest of the many projects for which the Board is responsible.

The Grudie Bridge station utilises the waters of Loch Fannich, and in a previous article* we described the construction of the tunnel and pipeline and the unusual method of making the underwater connection between the tunnel and the Loch. We also gave an outline of the Conon Valley scheme as a whole. In the present article it is our purpose to describe the station itself and the manner in which it will be integrated into the general scheme.

The generating plant consists of two 12,000 kW vertical Francis sets, and Grudie Bridge will be fol-

*"The Loch Fannich Development." *Water Power*, Oct. 1951, page 384

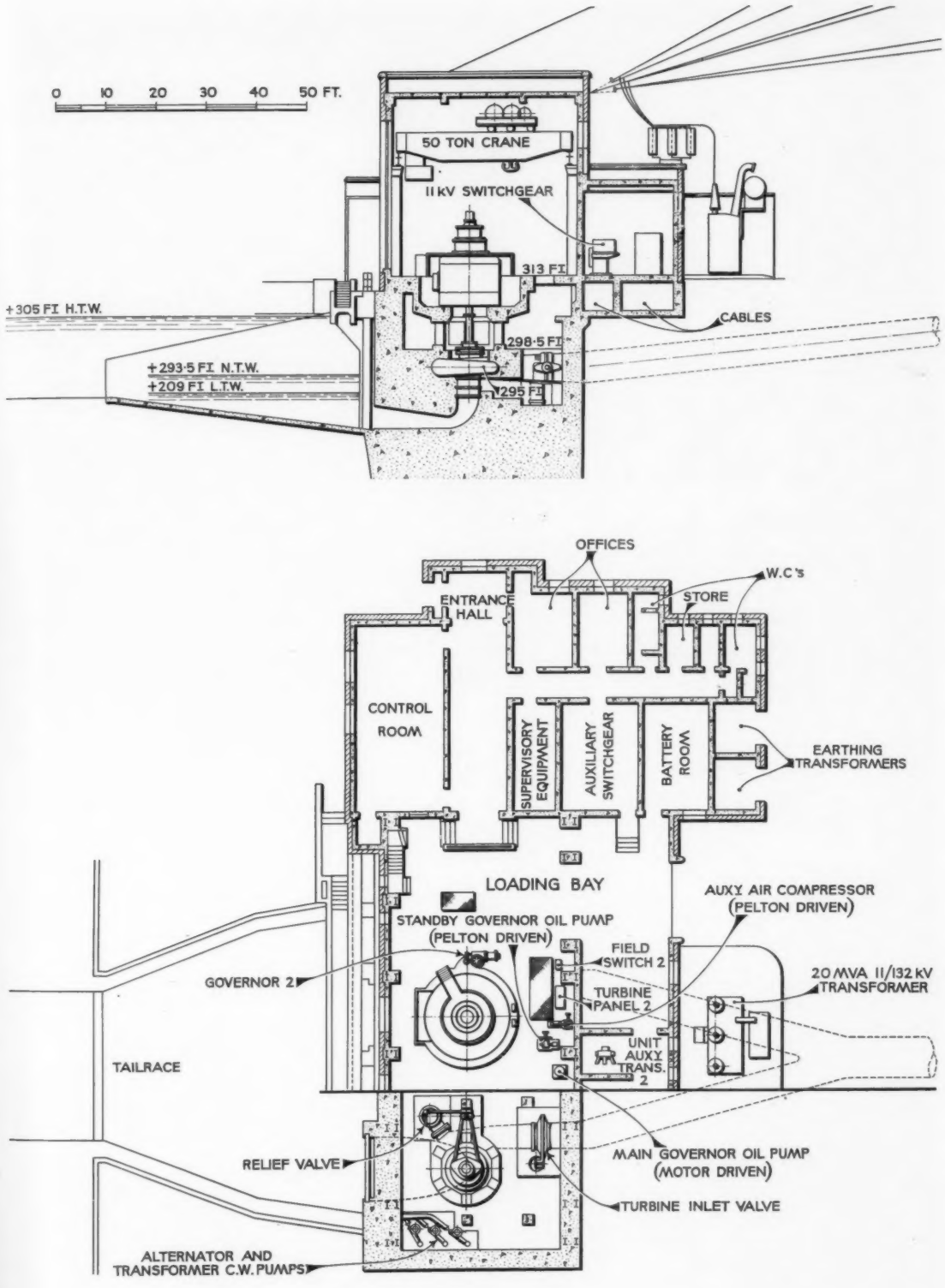


Fig. 1. Sectional plan and elevation of Grudie Bridge power station

lowed in due course by stations of similar capacity at Glascarnoch and Luichart and by smaller stations at Achanalt and Torr Achilty. A further station to develop the Orrin Valley is in the proposal stage. In order to provide the best possible amenities for the staff it is intended ultimately to control all these stations both mechanically and electrically from a central point, the individual stations, which will be in remote situations, being either lightly staffed or unattended except for travelling maintenance teams. As an interim measure, however, Grudie Bridge is being operated manually by a resident staff, though a control system has been provided to enable the turbines to be started and stopped either manually, automatically by local pushbutton, or by remote supervisory control at a later date. To this end automatic relays and alarms have been installed to check all essential quantities and movements. Electrically, also, the station is at present controlled locally but can ultimately be remote controlled. To ensure the utmost reliability in these conditions, the design of the equipment and of the station itself has deliberately been kept as straightforward as possible.

Fig. 2. The reinforced-concrete bridge and fish screen spanning the tailrace

Fig. 3. General view of the power house showing the 12,000 kW Bruce Peebles generators

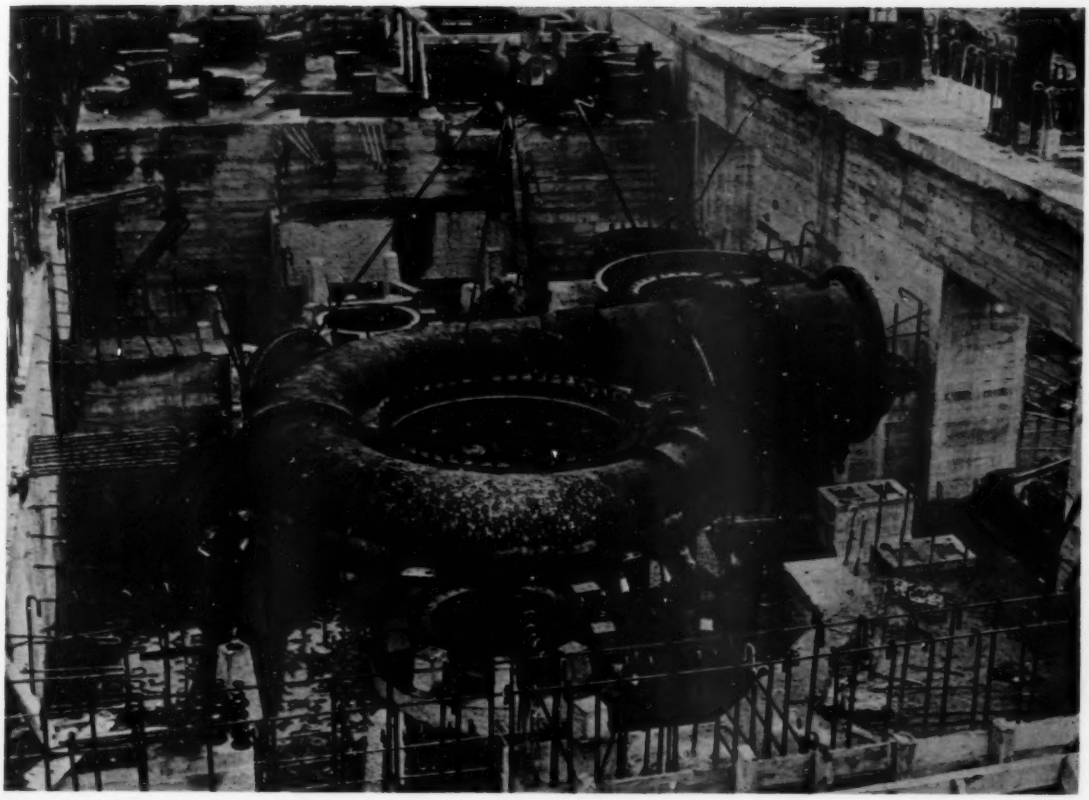


Fig. 4. The scroll casing of one of the 17,000 b.h.p. Harland turbines being lowered into position

Power House

A plan and elevation of the power station are given in Fig. 1. Before work was commenced on the station itself, a short diversion was made to the river Grudie so that the building foundations could be constructed in the dry. An ancient humpbacked bridge, which spanned the river at the point of the future tailrace was also replaced by a reinforced-concrete two-pinned portal-frame bridge.

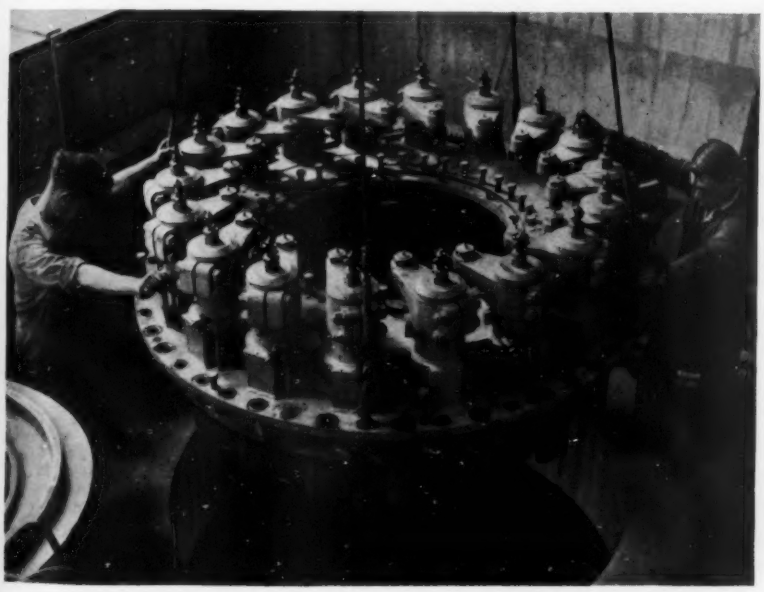


Fig. 5. The wicket-gate assembly of one of the Harland turbines

The power house is a steel-framed concrete structure faced with natural stone masonry and was built by J. Bissett & Sons Ltd., of Aberdeen, the architects being Messrs. James Shearer and Annand. The turbine room measures 85 ft. by 37ft., is of the two-floor type, and is served by a 50 ton Arrol crane. The turbine spirals, which are welded steel-plate fabrications, are concreted into the foundation block, and to facilitate this operation special jacking lugs with counter anchors were welded to the spiral to enable it to be rapidly located and positively held against flotation as the concrete was filled in. On the generator floor the generators are half sunk in reinforced-concrete wells, and as the turbine stay vanes were

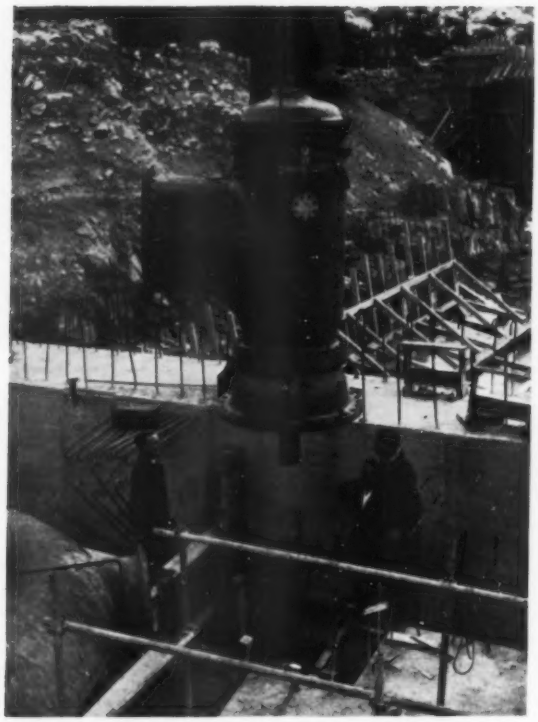


Fig. 6. Lowering one of the turbine relief valves into position

not designed to carry the load from the thrust bearing and the floors above, it was necessary to cantilever the supporting stanchions over the spiral casing and provide a bitumen membrane to allow deflection without transference of load.

Main Intake Valves

The turbine main inlet valves were built by Glenfield & Kennedy Limited as subcontractors to The Harland Engineering Co. Ltd. Each valve is 5 ft. in diameter and is of the balanced-disc type with horizontal trunnions. An 8 in. parallel-faced sluice-type bypass valve equalises the pressure across the disc before opening, but the main valve is capable of closing against full unbalanced pressure. Both main and bypass valves are operated by hydraulic servomotors using clean filtered water from the pipeline, and the supply to the main servomotor is controlled by a valve which retards the final closing of the main valve to reduce water hammer. The servomotor control valves are solenoid operated to admit of controlled sequence operation by pushbutton, and both main and bypass valves are fitted with limit switches for electrical interlocking and position indication. In an emergency the main valves can be closed from the alternator floor, 18 ft. above, by hand controls which operate the pilot valves directly.

Turbines

The turbines were built by The Harland Engineering Co. Ltd. to Morgan Smith designs. Each is guaranteed to produce 17,000 b.h.p. under a net head of 458 ft., and is designed to operate over a normal range of net head of 448 to 480 ft. and a maximum gross head of 549 ft.

In the construction of the turbines electric welding has been used to the fullest possible extent; draught-tube liners, pit liners, spiral cases, curb rings, bottom plates, head covers, bearing housings, gate-operating rings and connecting rods were all fabricated by welding, and all parts subject to pressure were stress relieved. The result is a rigid but economical design.

The turbine shaft, which is 14½ ft. in diameter, is of Siemens-Martin forged steel, and has a stainless-steel liner where it passes through the stuffing box. It is solidly coupled to the runner, which is a stainless-steel casting. Plain seals are employed, consisting of stainless-steel facings on the runner working with a small radial clearance within bronze rings in the casing.

The wicket gates are of cast steel with integral spindles and work between removable mild-steel wearing plates in the bottom ring and the head cover. The top and bottom gate clearance is adjusted by thrust collars mounted in the head cover, where they are readily accessible and are away from the water stream; this construction also relieves the wearing plates of all mechanical wear, reserving them for their true function of accepting hydraulic wear. Cast-steel gate arms are fixed to the gate spindles, and are connected to the operating ring by cast-iron links which are saw cut so that should a gate become jammed the corresponding link will break. An eccentric pin forms part of the linkage to each gate to enable wear between adjacent gates to be taken up.

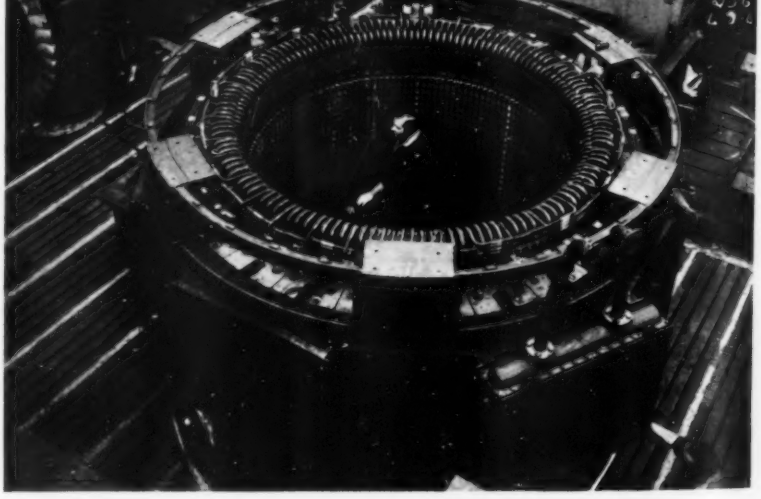


Fig. 7. The stator of one of the Bruce Peebles generators in the makers' works

To prevent cavitation, air is introduced through the runner at low gate openings and directly into the draught tube during overload.

To simplify maintenance, mechanical drives from the turbine shaft have been carefully avoided.

As described in our previous article, the surge chamber is upwards of 2,700 ft. from the turbines, and it was therefore necessary to equip each turbine with a relief valve. A relatively rapid closure of the turbine gates causes the relief valve to open immediately and maintain the velocity of the water column; subsequently the valve closes at a controlled rate such that water hammer is minimised. By the use of these valves the maximum pressure that occurs due to a sudden rejection of load is limited to 10 per cent.

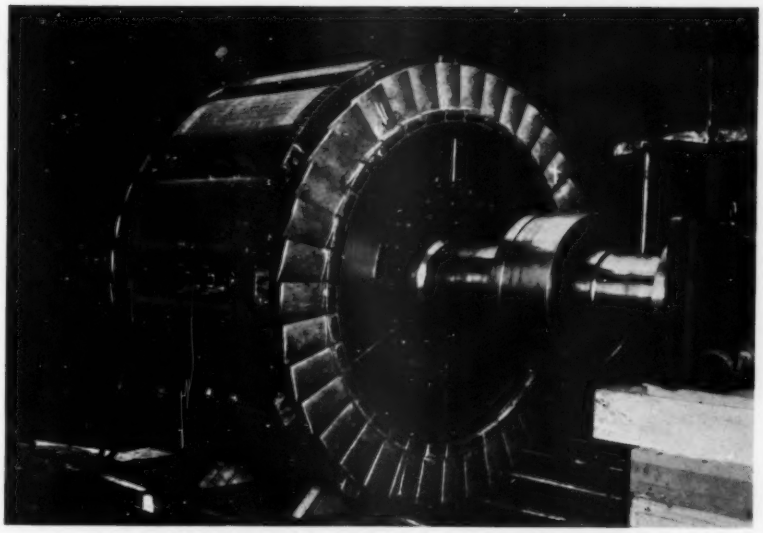


Fig. 8. The rotor of one of the Bruce Peebles generators

The governor is stated to be sensitive to a speed variation of one hundredth of one per cent. It is arranged to run the turbine up to speed under its own control on the pressing of a single pushbutton. An electrically driven speeder gear varies the speed between plus 5 per cent. and minus 15 per cent. of normal, the lower limit being useful for synchronising at low frequency during periods of heavy demand. There is also a speed drop adjustment which can be set at any value between zero and minus 5 per cent. to suit parallel running conditions.

For starting and stopping the machine under hand control, using the governor oil pressure, a hand-operated load-limiting device is provided. When no pressure oil is available the turbine gates can be controlled by hand gear.

Water flow through each turbine is measured by the pressure differential between the outer and inner radii of a section of the spiral casing, and is indicated, recorded and integrated by Electroflo instruments.

Generators

The generators were built by Bruce Peebles & Co. Ltd., who were the main contractors for the majority of the power-station plant. Each has a maximum continuous rating of 12,000 kW at 0·9 power factor at a normal speed of 500 r.p.m., and generates at 11,000 V three phase 50 cycles. The voltage tolerance is plus 10 per cent. and minus 15 per cent., and the inherent voltage regulation 13 per cent. at unity power factor and 23 per cent. at 0·9 power factor. At the rated output the efficiency is 97½ per cent. The rotor has a flywheel effect of 490,000 lb. ft^2., and is designed to withstand a runaway speed of 875 r.p.m.

The stator frame is of welded steel-plate construction, the core consisting of laminations built up on dovetailed keys which are welded to the frame after the core has been assembled. To prevent vibration of the teeth of the laminations, steel fingers on the end plates extend to the tips of the teeth, the end plates being heeled on the frame and the clamping bolts passed behind the laminations. Magnetic losses at the ends of the core are minimised by progressively cutting back the teeth of the laminations towards each end to increase the air gap. The windings consist of diamond-wound coils laid in open slots, and are insulated to Class B standard.

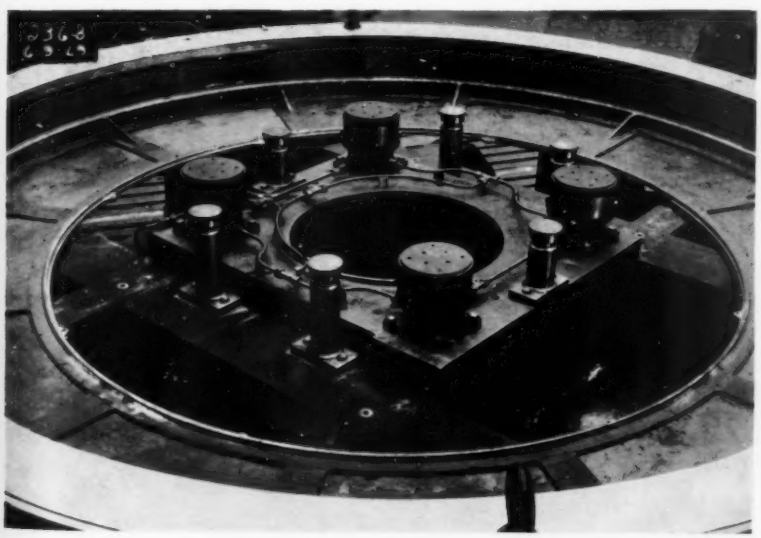


Fig. 9. Braking and jacking-gear assembly

The rotor body is built up from a series of rolled steel plates machined all over, shrunk on to the shaft, and secured by through bolts. Dovetailed grooves are machined in the assembly to receive the poles, which are built up of laminations between rounded end plates. Between the poles vee-shaped bronze clamps are bolted to the rotor body to secure the windings, which are of copper strip wound on edge. A damper winding is provided. On the underside of the rotor is a brake path consisting of six renewable machined segments in Meehanite cast iron secured by spring-loaded bolts to allow for thermal expansion without buckling.

A Michell-type thrust bearing and upper guide bearing are located above the rotor and a lower guide bearing below it, there being also a guide bearing on the turbine. The thrust and upper guide bearings are insulated to prevent shaft currents. The thrust bearing carries a total load of 85 tons, which is transmitted to the stator frame by a heavy fabricated spider. Seeing that the michine is a high-speed one the rotor diameter is comparatively small, and in default of special arrangements access to the lower guide bearing would be difficult. This problem has been solved by mounting the bearing housing on a pair of transverse beams, which can be removed to allow the housing to be lowered by a tackle. This also affords access to the brakes and jacking gear.

All four bearings are flow lubricated on a single system. Oil is held in a 400 gal. reservoir and is pumped to an overhead distributing box at 8 lb. per sq. in. whence control feeds descend to the thrust, top guide, lower guide, and turbine bearings respectively. Each bearing has a mercury-in-steel thermometer, the dial of which carries two adjustable contacts, the first to initiate an alarm, and the second, coming into action at a higher temperature, to shut down the machine before the conditions become dangerous.

The braking gear consists of four Tangye plain cylindrical hydraulic jacks covered with Ferodo pads. For braking purposes air is admitted to the oil reservoir at 80 lb. per sq. in. and the weight transferred to screw jacks. This system is preferred to that in which compressed air is admitted to the jacking cylinders

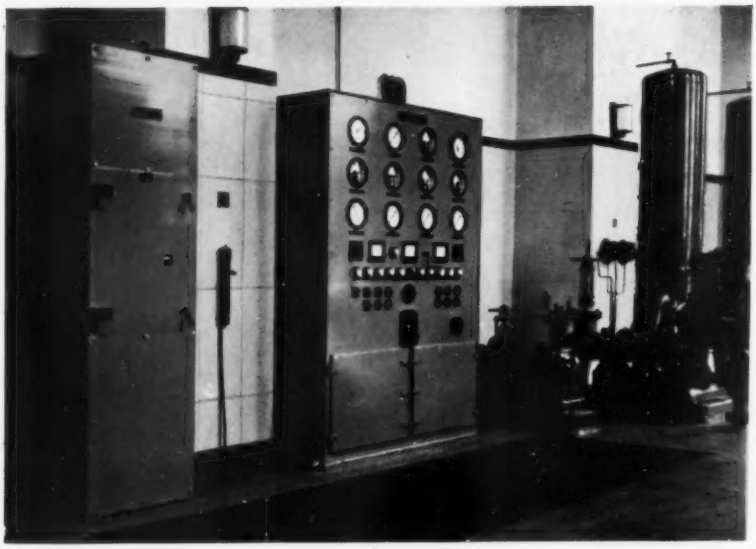


Fig. 10. The control and instrument cabinet and some of the auxiliaries for one of the turbines

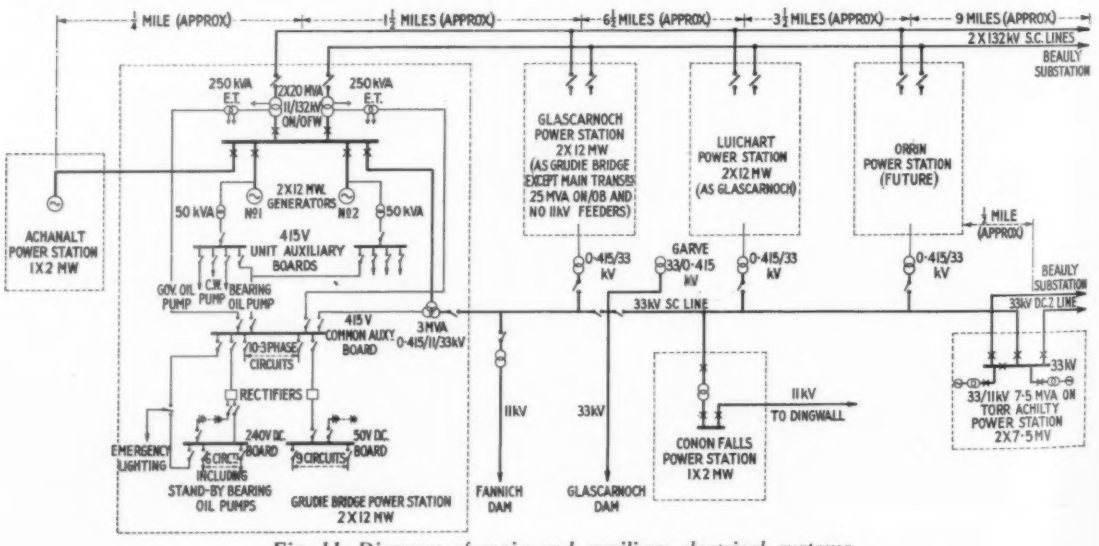


Fig. 11. Diagram of main and auxiliary electrical systems

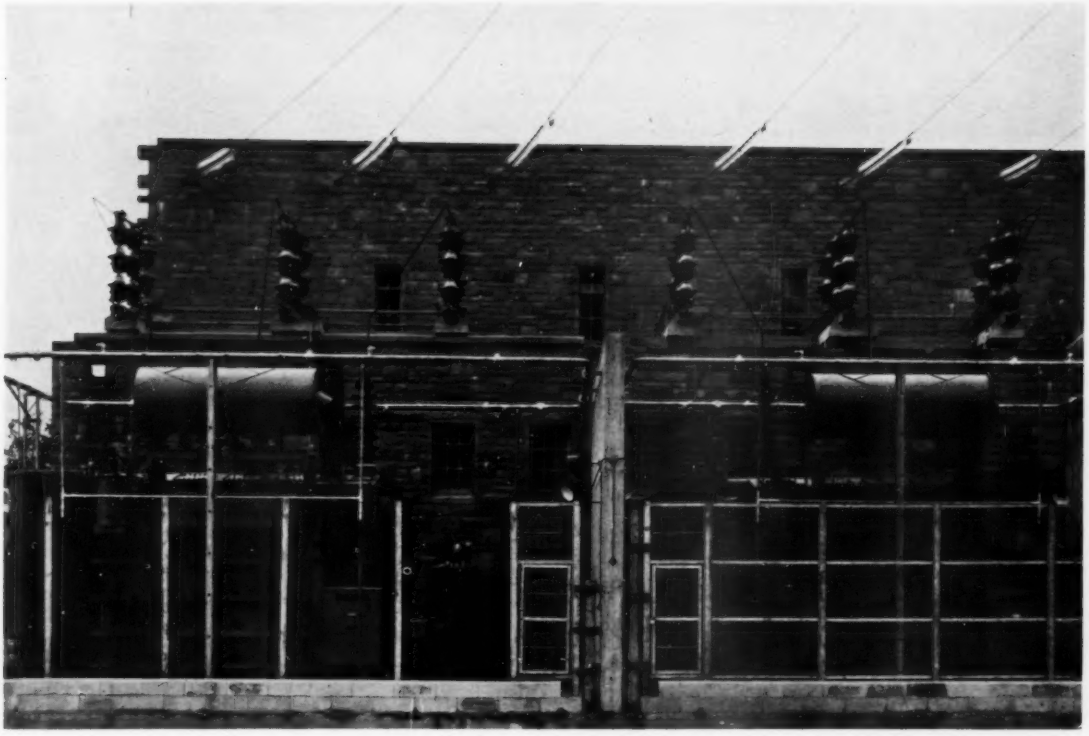


Fig. 12. Rear view of Grudie Bridge power station showing the two Bruce Peebles 20,000 kVA 11,000/132,000 V transformers

for braking, as the risk of oil aeration is avoided.

Surmounting the generator is a separate assembly consisting of the main and pilot exciters and, at the extreme top, the permanent-magnet alternator which drives the turbine governor.

Incorporated in the permanent-magnet alternator assembly are overspeed and underspeed switches, these being of the self-resetting snap-action mercury type. The overspeed switch operates at 30 per cent. overspeed, and the underspeed switch is interlocked with the brakes so that in the event of an emergency shutdown the brakes cannot be applied until the speed is reduced to 95 per cent. of normal speed. Under normal conditions the brakes are locked out until the speed is reduced to 50 per cent. of normal.

The entire exciter assembly can be lifted away as a unit, leaving the sliprings exposed.

Cooling of the alternator is on the closed-circuit system, six Serck coolers being disposed round the stator frame. In cold weather the system can be used for station heating, make-up air being drawn in through Fibreglass air filters.

Auxiliaries

Three 24 h.p. vertical electrically driven circulating-water pumps are provided, one for each set and the third as a standby. Water is supplied to the alternator, lubricating-oil and transformer-oil coolers, and flow relays give an alarm if the supply to any cooler is arrested.

An electrically driven 7½ h.p. gear-type governor-oil pump is allotted to each turbine. In each case the oil is stored in an air receiver, the pump unloading when sufficient pressure has been attained. As the pump also delivers the air required, a high-pressure air compressor for normal operation is avoided, although a Pelton-driven compressor is available as standby, and the governor-oil pressure receivers of the two sets are interconnected. A standby Pelton-driven governor oil pump is also provided, and comes into action automatically if the oil pressure becomes low. It can also be started and stopped by hand. Pressure switches are fitted to the governor-oil-pressure receivers to give an alarm and shut down the machine at a predetermined low pressure.

Each machine is also provided with an a.c. motor-driven lubricating-oil pump and a standby d.c. motor-driven pump. Other auxiliaries include a motor-driven brakes air compressor, a self-priming drainage pump operated by float switch, a dewatering pump for emptying the draught tube, which also acts as a float-switch-controlled standby drainage pump, and four transformer-oil pumps. The standby governor-oil air compressor can supply air to the braking system.

Main Electrical System

A diagram of the main and auxiliary electrical connections is given in Fig. 11.

The two generators feed a common busbar from which the supply is taken through two Bruce Peebles 20,000 kVA 11,000/132,000 V delta-star outdoor-type oil-immersed transformers. Each main transformer is earthed by means of a Bruce Peebles 250 kVA 11,000/415 earthing transformer which also affords a low-voltage supply for the station.

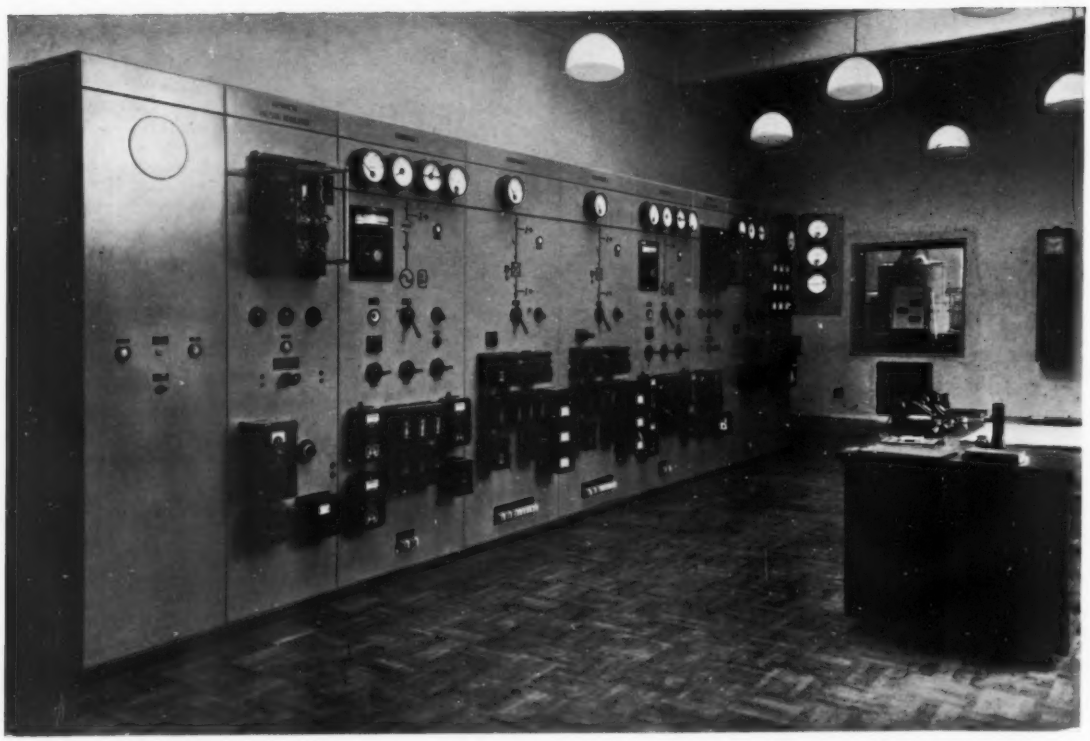


Fig. 13. The control room showing the Reyrolle main control board

The main transformers are of the core type. On the high-voltage side tappings covering a range of plus 15 per cent. in eight steps are taken out to a linking chamber arranged so that on-load tap-changing gear can be installed when required. The high-voltage side has been subjected to an impulse test of 640,000 V.

The cooling arrangements are interesting and have been designed to fit in with the ultimate requirements of remote station control. Natural cooling by means of four radiators is provided to cater for no-load losses only, forced cooling through water coolers being employed whenever the transformer is on load. Each transformer has a double water cooler, either half of which is adequate for full transformer load, equipped with hand-operated valves so that either or both halves can be brought into service. Duplicate oil pumps, each capable of dealing with full load, circulate oil to a duplex valve which can distribute the oil to either or both halves of the water cooler or can shut the oil off. Flow alarms are fitted to both oil and water circuits; failure of an oil pump automatically brings the other into service, and a potentially dangerous condition brings the transformer out of circuit. An oil-pressure regulator is fitted to the outlet side of the cooler to ensure that the pressure of the oil is always above that of the water. A winding-temperature indicator and alarm and double-float Buchholz device are also provided.

Each transformer weighs 73 tons complete and 62 tons ready for transport, and, as may be imagined, their transport to this remote site called for a measure of resourcefulness.

The main 11,000 V switchgear was built by A.

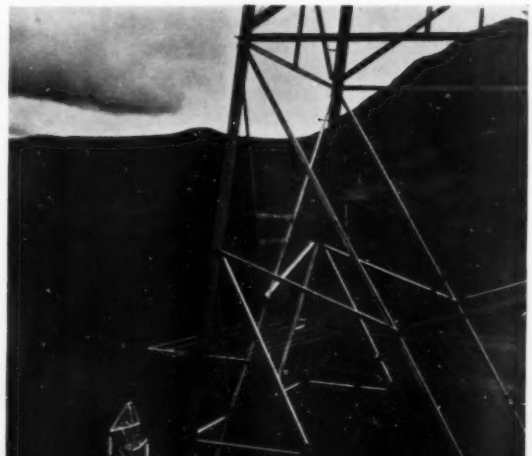


Fig. 14. An impression of the two single-circuit 132,000 V Henley transmission lines showing the steep gradients to be negotiated

Reyrolle and Co. Ltd., and consists of five single-busbar solenoid-operated oil circuit-breaker panels of the horizontal drawout pattern having a breaking capacity of 500 MVA. It is housed in an annexe and is protected against fire by Pyrene automatic CO_2 equipment. The switchgear can be operated locally at the panels for testing or emergency purposes, but is normally controlled from a suite of instrument and relay panels situated adjacent to the entrance hall. These panels are of sheet-steel cubicle construction and are finished in light battleship grey with black fittings. They include a diagram of the main connections and accommodate Metropolitan Vickers voltage regulator equipment as well as telephone-type alarm equipment of Standard Telephones and Cables manufacture. Provision for position indication and closing of the portal valves is also fitted and provision has been made for future supervisory remote control. The associated control cables and 11,000 V main cables were supplied by Standard Telephones and Cables Limited.

Fig. 15. The Reyrolle 11,000 V, 500 MVA main circuit breakers

Auxiliary Electrical System

The essential auxiliaries for each generating set—governor-oil, bearing-oil and circulating-water pumps—are supplied through a 50 kVA Bruce Peebles unit transformer feeding a Contactor Switchgear Limited unit auxiliary board at 415 V. Normally the starters for these auxiliaries are latched in so that the pumps run up to speed with the set they serve. Other electrically driven equipment is supplied from a Reyrolle 415 V common services board, which can be energised by any of three transformers—the two Bruce Peebles 250 kVA earthing transformers associated with the two main transformers, and a 3,000 kVA triple-wound 415/11,000/33,000 V linking transformer fed from the main busbars and connected to a local 33,000 V grid. A Brookhirst selector panel automatically chooses one of these transformers in a predetermined sequence, and in the event of a failure of the transformer on supply, transfers to the next healthy transformer in sequence. A connection can also be made from the common services board to either or both of the unit auxiliary boards, which can themselves be coupled together.

Direct current is available at 240 V for standby auxiliaries and control circuits, and at 50 V for alarms and telephones, from two Chloride batteries. The charging rectifiers are supplied from the 415 V common services board, and distribution is effected by Bertram Thomas flat-back switchboards. Emergency lighting can be derived either from the common services board or from the 240 V d.c. supply.

Cables for the auxiliary circuits are neatly disposed on tray-type metal racks, and lighting and similar circuits are run in Pyrotenax cable.

Station Control

As mentioned at the beginning of this article, Grudie Bridge station is designed to be remote controlled ultimately. Actually three types of control are available: Direct manual control, by which all operations are carried out by normal hand controls; manual pushbutton control, by which each item of equipment is started and stopped individually by pushbutton; and semi-automatic control, by which the pressing of a single pushbutton either at Grudie Bridge or at the control centre brings the generating set concerned to the "set on busbars" condition.

The first two systems call for little comment, but the semi-automatic control is of particular interest. A sequential-parallel method of control has been adopted whereby the slowest preliminary operations in starting the machine are carried out simultaneously to minimise the overall starting time. Thus, pressing the control button simultaneously starts the standby governor-oil and bearing-oil pumps and opens the bypass valve. When the spiral casing has filled and the pressure across the main shut-off valve has equalised, the main valve opens and, when this movement is completed, the bypass valve closes. As soon as the various relays indicate that all these operations have been completed and that the alternator brakes and jacks are off, the governor solenoid is energised, and the turbine runs up to speed. The essential auxiliaries—governor-oil, bearing-oil and circulating-water pumps—run up in unison with the turbine, as their motors are fed from the unit transformer, and as they come up to speed the standby auxiliaries automatically cut out. An indication is then given that the set is ready for synchronising, which operation will then be carried out automatically by equipment located within the power station. Should the starting sequence fail at any point the whole operation is cancelled and the nature of the defect is indicated on the alarm panel.

When the automatic stop button is pressed, the governor solenoid is de-energised, causing the turbine gates to close, and the main inlet valve is closed.

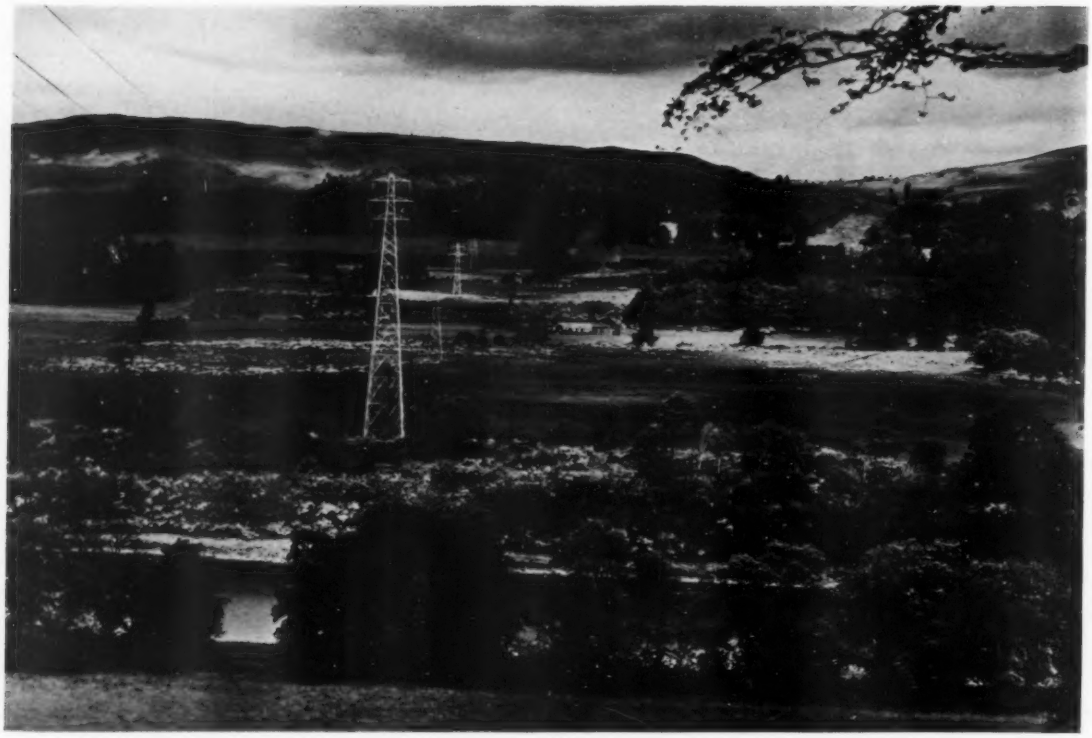


Fig. 16. Part of the double-circuit section of the transmission line to Beauly

When the speed of the set has dropped to 50 per cent. of normal the alternator brakes are applied and after a time lag sufficient to ensure that the turbine has come to rest they are released. The essential auxiliaries automatically shut down with the main set, and when the bearing-oil pressure falls below a predetermined value the standby bearing-oil pump runs up, shutting down again after a time sufficient to ensure that the turbine has stopped. The automatic stop button will not operate unless the machine has been taken off load and the main circuit breaker opened.

Electrical Transmission

Power from Grudie Bridge is taken to a substation at Beauly, some 20 miles away, where is is joined by a line from Fasnakyle and thence proceeds to Boat of Garten, ultimately feeding the system supplying the whole of north-east Scotland. Reverting to the circuit diagram, Fig. 11, Grudie Bridge is connected to Beauly by two 132,000 V circuits, each supplied by one of the main transformers, which are not interconnected on the high-voltage side. A supply is also given through the linking transformer to the local 33,000 V line from Beauly. Fig. 11 also shows the manner in which the future stations will be coupled into the system.

The high-voltage transmission line from Grudie Bridge to Boat of Garten, including the connection from Fasnakyle, involved the erection of some 75 miles of steel-tower line, and was erected by W. T. Henley's Telegraph Works Co. Ltd., the consulting engineers being Messrs. Kennedy & Donkin. Owing to the remote and rugged nature of the terrain a normally straightforward piece of work became one of some difficulty and of unusual interest. Lightning storms are prevalent in the district between Grudie Bridge and Beauly, and to minimise interference from this source, the two circuits were run over this region as separate single-circuit lines about 150 ft. apart. For the remainder of the contract the lines were run on double-circuit towers.

Transport in this inaccessible region proved a real problem, and tractors, winches, mules, aerial ropeways, and an improvised funicular railway were all brought into service. At certain tower sites everything had to be manhandled. The ground ranged from solid rock to peat and running sand, and this, together with the predominance of hillside slopes, in many instances involved the design of special foundations.

Typical views of the transmission lines are given in Figs. 14 and 16.

Acknowledgments

This article is published by kind permission of the North of Scotland Hydro-Electric Board, who have afforded us every facility in allowing us to visit the works and in assisting us with information and photographs. We are also happy to acknowledge our indebtedness to Sir Alexander Gibb and Partners and to Messrs. Merz and McLellan, the consulting engineers for the civil and for the mechanical and electrical sides of the work respectively, who have given us valuable assistance. The architects for the power-station building were Messrs. James Shearer and Annand.

Bruce Peebles & Co. Ltd. were the main contractors for the majority of the power-station plant, and a

list of the principal contractors is given hereunder:—

Turbines, governors and relief valves	The Harland Engineering Co. Ltd.
Main inlet valves ...	Glenfield & Kennedy Limited.
Water pumps ...	The Harland Engineering Co. Ltd.
Oil pumps ...	Mirrlees, Bickerton & Day Ltd.
Compressor ...	Broom & Wade, Limited.
Alternators and exciters	Bruce Peebles & Co. Ltd.
Turbine house crane	Sir Wm. Arrol & Co. Ltd.
11 kV and auxiliary switchgear ...	A. Reyrolle & Co. Ltd.
Main and auxiliary transformers ...	Bruce Peebles & Co. Ltd.
11 kV cables ...	Standard Telephones & Cables Limited.
Lighting, heating and auxiliary cabling	Matthew Hall & Co. Ltd.
Alarm and relay system and automatic control equipment ...	Standard Telephones & Cables Limited. Contactor Switchgear, Limited.
Tunnel	Balfour, Beatty & Co. Ltd.
Pipeline	Mechans Limited.
Power-station buildings and pipeline foundations ...	J. Bissett & Sons Ltd.
132 kV transmission lines	W. T. Henley's Telegraph Works Co. Ltd. (Consulting engineers, Messrs. Kennedy and Donkin.)

Book Reviews

Cofferdams.

By Lazarus White and Edmund Astley Prentis. Columbia University Press, New York, 1950. 304 pp. 201 ff. Price 63s. net. In the preface the authors state that "practicing engineers justly demand that the author of an engineering book have a long record of successful accomplishment in the field about which he is writing." Doubtless their long experience, as contractors, of the construction of dams and locks in the very fine sands of the Upper Mississippi River gives impunity to this statement.

The subject is handled systematically in six sections: (i) Hydrodynamics of cofferdams, (ii) Erosion in streams, (iii) Lateral earth pressures, (iv) Land cofferdams, (v) Practical considerations, (vi) Examples of cofferdams. The first five sections are packed into 120 pages without apparent cramping, while the sixth section is given the run of 155 pages without any waste space.

The hydrodynamics section concentrates on seepage through or under cofferdams as distinct from flow over or round them. Fundamental principles are reviewed "as free as possible from mathematical theory." The important phenomenon of "quickness" or "boiling" in fine sand is elucidated at length, with reference to laboratory and larger practical models. Apparently the authors favour open ditches and efficient centrifugal pumps for large areas rather than deep wellpoints. Stream erosion covers the cause and avoidance of erosive currents and scour, as exemplified by actual field experience and model experiments, for normal and overtopped conditions.

Lateral earth pressure conceptions are reviewed from Coulomb to Terzaghi; results of tests on full-size field trenches are given; land cofferdams cover the wellpoint system and the features necessary for successful operation. The advantage of an inside berm in preventing quickness or boiling of fine ground is stressed. The practical considerations section clarifies cofferdam types and suitabilities and the proper stages of crossing and closing rivers; reiterates the importance of an inside berm, gives examples of pumping requirements and leads naturally to the largest section of the book—Examples.

The fifteen examples given include earth dykes on earth and on rock; earth dykes with wellpoint drainage; single and double walls with earth fill; isolated bridge pier cofferdams; the Ohio type dam; cellular steel dams; timber cribs and land cofferdams for large foundations. The descriptive matter has the flavour of the "works" report suitably seasoned with after-the-event observations and second thoughts, in which teething troubles, nasty moments and even collapses are freely described and illustrated by diagrams and photographs.

Two appendices—one miscellaneous photographs, the other a list of wages and prices (American)—and a chronologically arranged bibliography complete the book, which is well produced and clearly illustrated.

Engineering Hydraulics.

Edited by Hunter Rouse. Proceedings of the Fourth Hydraulics Conference, Iowa Institute of Hydraulic Research, June 12 to 15, 1949. John Wiley & Sons, Incorporated, New York, and Chapman & Hall, Limited, 37 Essex Street, London, W.C.2. 9 in. × 6½ in. × 2 in. pp. xiii and 1039 including index. Illus. Price 120s. net.

Progress in most sciences takes two forms—one is the advance into hitherto unknown territories by the observation of natural phenomena, and the other the interpretation and correlation of the new data and a synthesis of the various interpretations.

The lively stimulus for research into fluid mechanics, particularly on the side of aerodynamics, has in the past few decades resulted in remarkable progress which has profoundly influenced the applied science of hydraulics. The publication in 1949 of Charles Jaeger's "Technische Hydraulik," and in 1950 of the present volume edited by Hunter Rouse indicates that the time is ripe for a collection and synthesis of individual researches.

The purpose of this very handsome publication is to provide a broad picture of the present state of knowledge in the applied science of hydraulics and to furnish the student, the practising engineer and the research worker with a comprehensive reference book. The method of achieving this purpose deserves special mention: Professor Hunter Rouse and a dozen other leading American hydraulic engineers con-

tributed a draft chapter each on his special field of study to over 400 engineers gathered together at the 1949 Iowa Conference for the sole aim of improving these drafts. The book, therefore, represents the result of a co-operative effort unique in hydraulics.

The nature of the volume implies that each chapter is a condensation of a large amount of detailed information, and the largely American bibliographies appended to each chapter point the way to original sources and specialised data.

Fundamental principles of flow, while clearly evident throughout the work, form the subject of the first and chief chapter which can be described as a good résumé of Hunter Rouse's most excellent book on " Elementary Mechanics of Fluids. "

The last chapter, on hydraulic machinery, also a major contribution of over 130 pages, is a fitting conclusion in its useful treatment of the theory and practice of pumps, turbines and hydro-dynamic transmissions, as well as positive-displacement machinery.

Hydrology, the subject of another major chapter, deals with the associated sciences of meteorology and climatology before giving a summary of the present state of knowledge on rainfall and run-off and their relation.

A further important chapter deals with sediment transport, both in some of its theoretical aspects and in such practical applications as canal and river design, silting of reservoirs, beach movement and silt traps.

Hydraulic similarity is discussed together with its application to the design and operation of models of various kinds. The chapter on flow measurement deals not only with methods and equipment for measuring discharges, but surveys methods and instruments for measuring length, time, force, pressure, mass, velocity and turbulence, and discusses the degree of accuracy obtainable and needed in practice.

A useful introduction to the theory of ground-water flow and its application leads up to the problems of wells and recharge wells, including unsteady flow through permeable materials.

Two interesting chapters are devoted to steady flow in pipes and conduits and to surges and water hammer, and are followed by chapters on channel transitions and controls, and on gradually varied (steady) channel flow. These four chapters the designer, however experienced, is likely to find very useful, for they lucidly relate to the fundamentals such problems as friction loss, form resistance, the behaviour of complicated systems of conduits, open-channel flow both tranquil and rapid, and flow in the vicinity of hydraulic structures.

The general problem of unsteady flow in open channels as well as the particular case of the effect of a flood inflow into a reservoir or a river channel or system are included under the heading of flood routing, and some mechanical and electrical devices for flood routing — in effect special calculating machines — are mentioned. Open-channel surges, however, are treated as part of the chapter on wave motion which deals comprehensively with gravity and also with capillary and elastic waves and includes density currents as a particular form of surges.

A valuable appendix contains a dissertation on dimensional considerations, and gives a number of properties of common fluids, as well as a list of symbols used in the book.

The practical value of the work is increased by numerical illustrations of methods of computation, often helpful in explaining difficulties not apparent in a series of mathematical formulae, though it should be stressed that advanced mathematics have been avoided, so that an engineer with an average knowledge of undergraduate mathematics can confidently approach the book. As the title implies it is two stages removed from the theoretical " Hydrodynamics " of Lamb, and barely overlaps with the intermediate " Modern Developments in Fluid Dynamics " of Goldstein. Undoubtedly it will find a place in the library beside those classics.

The only criticism which might occur to a British reader, apart from the regret that the price will be beyond the pocket of most students, would be based on a feeling that the authors show signs of insularity: for instance, Chapter IV on Hydrology might with advantage include examples of the climates of other continents; Chapter I might mention the existence of Southwell's powerful method of Relaxation in the mapping of flow nets; and could not Chapter XIII of a volume which so persuasively impresses on hydraulic engineers the significance and value of dimensionless parameters, mention the possibility of reducing " specific speeds " to such general forms as Addison's " shape number "?

In conclusion, the book is an outstanding addition to hydraulic literature and should be of great value to all students of engineering hydraulics. It is theoretically sound, contains a great number of experimental data supplementing the theory, and is frank and stimulating about the limitations of present-day knowledge. P.O.W.

Ransomes & Rapier Limited. A series of leaflets issued by this firm relate to " Rapier 8 " mobile cranes, portable electric wharf winches and the " Rapier 5 " super-mobile crane; the last named can be arranged for petrol, electric or diesel-electric drive and provided with either solid or pneumatic tyres.

Hydraulic Turbines. A 28-page bulletin under this title presents a brief story of some of the achievements of the Dominion Engineering Works Ltd., of Montreal, Canada, illustrating the various types of turbine they manufacture and giving particulars of some of the plants where they have been installed. A section on field tests of actual installations is of particular interest.

Ercole Marelli & Co. S.P.A., Milan. A handsomely produced brochure issued by this organisation gives a general survey of its activities which include the manufacture of the largest sizes of central-station generators down to fractional horse power motors. Other products related to hydro-electrical work comprise synchronous condensers, transformers and pumping sets for pumped storage installations.

Air-to-Water Heat Exchangers. Bulletin 05B 7682 received from the Allis-Chalmers Manufacturing Company of Milwaukee describes the advantages and limitations of their totally enclosed motors fitted with air-to-water heat exchangers, which are claimed to eliminate the entry of dust, dirt, fumes or excess moisture and so prolong the life of the machines and reduce maintenance.

Fig. 1. Storage dam for 287 kVA scheme on Fuluasou river

Fuluasou Hydro-Electric Scheme

Fig. 2. Close up of spillway section of storage dam which impounds 1·4 million cu. ft. of water

THE hydro-electric scheme on the Fuluasou river, in Apia, Samoa, was engineered by the Department of Island Territories in Wellington, New Zealand, under whose jurisdiction these islands are governed. The scheme comprises a single unit, and the prime mover is a twin "Turgo" water turbine constructed by Gilbert Gilkes and Gordon Limited, of Kendal, Westmorland, and is coupled to a 287 kVA B.T.H. alternator, generating at 400 v. 3-phase 50 c/s.

The reservoir stores 1,400,000 cubic feet of water, and from the dam a pipeline, comprising 8,245 feet of steel pipe, 3/16 in. in thickness, runs to the power house, giving an effective static head at the turbine of 206 feet. The pipeline was solidly welded, using slip-type joints with an average lap of $1\frac{1}{4}$ in., and the erection welds consisted of a run of No. 10, followed by a run of No. 8. Twenty-four expansion joints are fitted in the run, and during welding the maximum expansion at any joint was $1\frac{3}{4}$ in. This was due to the combined action of sun temperature reaching 94°F., and the build up due to absorption of heat from the welding process which combined to give an inside pipe temperature of 153°.

Abstracts from the World Technical Press

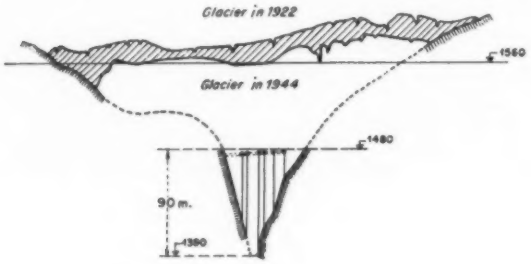
Exploration of Glaciers in Depth

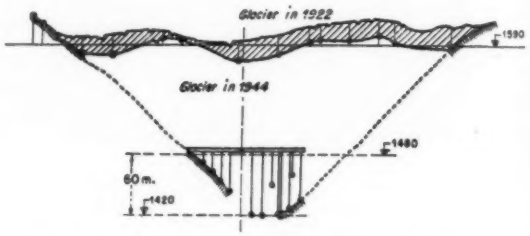
The authors of this paper read by M. Ract-Madoux before the Glaciology Sub-Committee of the "Société Hydrotechnique de France," describe the investigations made in 1944 and 1949/50 by two expeditions set up with a view to determining the potentialities of the sub-glacial storage of the "Mer de Glace" for hydro-electric purposes. This huge glacier actually constitutes the main reserve of water for the Arve valley and can supply yearly over 260 million cu. yards, a truly remarkable figure for a catchment area of no more than 18,500 acres.

Two quite dissimilar projects are in competition for the future harnessing of this glacier to power generation. One, a private scheme, envisaged the amalgamation in a single run-of-river fall at the Tines, above Chamonix, the resources of the Tour, Argentière and Mer de Glace glaciers with intakes at about 4,750 ft. above sea level. The other, initiated later by the French Electricity Authority, considerably wider in scope, involves greater difficulties; a collecting tunnel, built with an intake 5,570 ft. above sea level, is to convey the waters of the Mer de Glace, together with those of the Bossons, Bionnassay and Miage glaciers to the Roselend reservoir.

The exploration work connected with the older scheme was carried out by means of galleries driven in the ice (Figs. 1 and 2), from which vertical boreholes were drilled right down to the bed rock. The galleries had to be driven by means of hand picks; trials with explosives failed, owing to the fact that the ice breaks into small crystals which agglomerate and prove as difficult to remove as before blasting. The first hundred metres were driven at the rate of 5 metres a day but the plasticity of the ice caused the galleries to shrink, and work became more difficult as the galleries increased in length. Timbering proved useless.

In the second project the exploration work carried out in 1949 and 1950 consisted exclusively of soundings, either thermal or purely mechanical. In thermal soundings, a simple non-insulated resistance plays the part of the boring kit; this resistance, 1 metre in length, consists of a conical winding with a maximum external diameter of 50 mm. The wire ends are connected to the electrodes of a brass cylinder in such a way as to enable damaged "bits" to be easily exchanged for new ones; current was supplied by





Figs. 1 and 2. Exploration of glaciers by means of galleries and boreholes driven down to bedrock

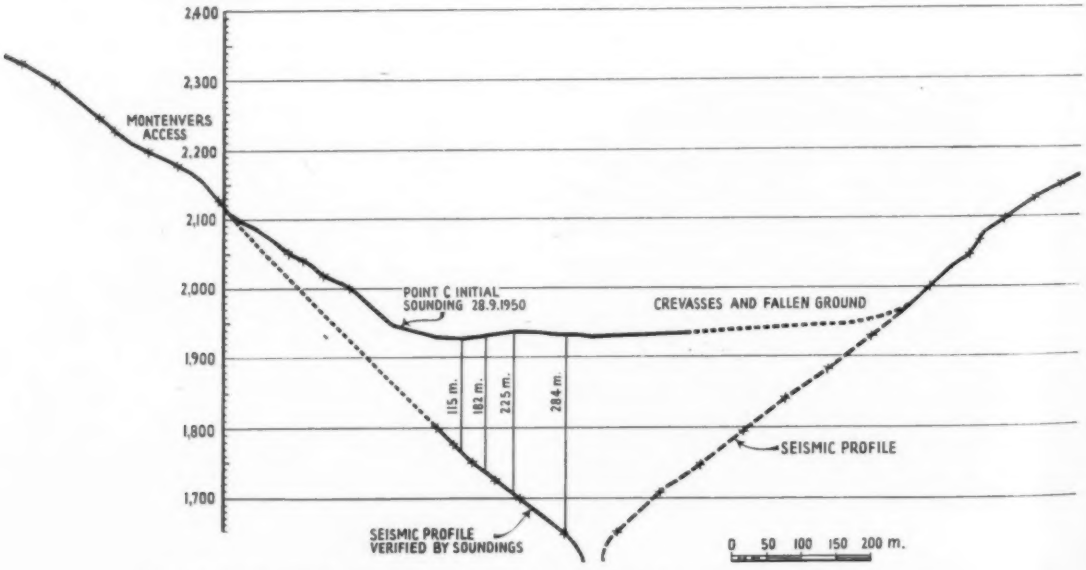


Fig. 3. Four soundings driven to a maximum of 284 m. to verify seismic profile

small petrol-driven generating sets. Under very favourable conditions, boring progressed at the rate of 24 metres per hour but the average of advance was much slower. This method, however, made it difficult to ascertain beyond doubt the presence of the bed rock.

This led to the adoption of a rotary boring machine with a core-cutting attachment. A first attempt reached the rock at a depth of 114 metres and to extract a 3 metres long core, and a second machine of the same type was eventually put into operation. Success was unfortunately impaired by many incidents, nevertheless an aggregate length of 1,500 metres was drilled, and four soundings reached the bed rock at 115, 184, 225 and 284 metres respectively (Fig. 3), this last figure being considered a record; it is expected that improved equipment will enable soundings of 300 metres to be taken.

The difficulties encountered and possibilities of remedying them are discussed at length, and the equipment used is described in detail. The most serious hurdle to be overcome in glacier soundings of this kind is the presence, in the wall of the borehole, of fissures through which the injection water escapes; this inconvenience is particularly grave when debris accumulate at the mouth of the fissure, and subsequently settles and freezes again so as to form a plug. If this plug cannot be removed in a matter of minutes, the sounding is a total loss; salt water did not prove efficient in dealing with these plugs and, ultimately, simple injections of hot water solved the problem. A further extensive range of soundings is to be taken this year and, in view of the experience previously gained, more satisfactory results are expected. (M. Ract-Madoux and L. Reynaud, "*Mémoires & Travaux de la Société Hydrotechnique de France*," Vol. 1, 1951, p. 89, 10 pp., 15 ff.).

New Transalpine Transmission Line

North Switzerland draws a substantial part of its electrical energy from hydro-plants. Until recently this supply was ensured by the three-wire St. Gothard line, built in 1932. Owing to increasing requirements and in view of the difficulty of adapting the existing line to a higher voltage, the Atel concern (Aar & Tessin Electricity Co.) decided to double the transmission capacity between the Tessin power plants and the distribution centre of Mettlen, near Lucerne.

Fig. 1. Route of the new transmission line

The new line, which was put into service end of 1949, is divided into two main sections: the Amsteg-Mettlen section which duplicates the original line, and the Lavorgo-Amsteg or Lucanier section, set up east of the old St. Gothard line. The voltage has been temporarily fixed at 150 kV, the conductors are, however, provided for a future increase to 225 kV, and the supports are throughout designed for an ultimate service tension of 380 kV.

A special feature of this line is that it is carried

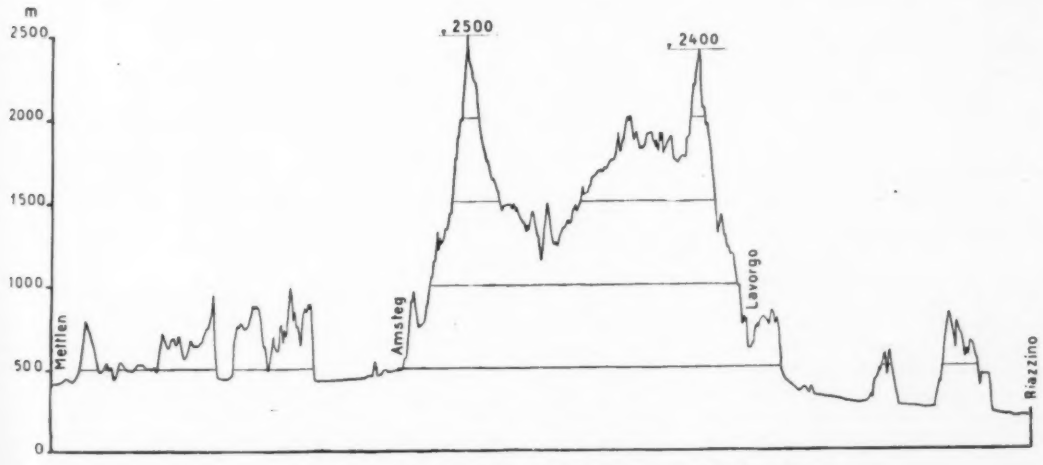


Fig. 2. Profile diagram of the new transmission line

exclusively by lattice towers made of concrete-filled steel tubes which, under equal load, ensure a much higher resistance to buckling, so that it is possible to increase considerably the length of individual steel sections while substantially reducing the weight of the towers. The resulting economy in steel, as compared with towers made of solid steel sections, exceeds 50 per cent. In order to facilitate the transport of components to the erection site, the tubes were, as a rule, filled with concrete after the tower had been assembled. An uncommon characteristic of these towers is that, when erected on very steep slopes, they have legs of widely differing length; for instance, on the Lucmanier section this difference reaches in some instances 42·65 ft.

This new section (Lavergo-Amsteg) is a typical example of a high-altitude line; about 32 miles in length, it crosses two mountain ranges at a height of 7,874 and 8,202 ft. respectively. Owing to very severe winter conditions, uncommonly high overloads had to be taken into account when calculating the various elements of the line. Because of the uneven ground and the lack of access road an extensive system of cableways totalling about 24 miles in length was provided for the transport of equipment to erection sites; the laying of the conductors also presented great difficulties, owing to the impossibility of conveying the cable reels to the vicinity of the sites. On two particularly difficult portions of the line, it was necessary to pull out at a stroke lengths of cable of 6,561 yards, weighing about 10 tons.

Conditions were considerably easier on the Amsteg-Mettlen section which, with its double three-conductor system actually forms the prolongation of the two single three-conductor St. Gothard and Lucmanier systems. On this section, the towers vary in height between 170 and 220 ft., against 134·5 and 85 and 138 ft. on the Lucmanier line.

The new line, as well as the old St. Gothard line, will be subsequently connected to the Maggia hydro-plants, now in course of construction near the Italian border, by means of the Riazzino-Lavorgo section.

The present tension of 150 kV in the two three-conductor systems will be increased to 225 kV when the Maggia plants are in operation. Subsequently, when the increasing demand of energy makes it necessary, the whole of the system will be re-adapted for an ultimate tension of 385 kV, and the transport capacity of the system will rise to about a million kW. (R. Vögeli and R. Leresche, *Bulletin de l'Association Suissa des Electriciens*, Vol. 42, No. 3, 10.2.51, 5 pp., 10ff.)

Deterioration of Transformer Oil and Paper Insulation

The following samples were used in the tests, viz., oil; oil with tough-pitch copper; oil with oxygen-free copper; oil and untreated manilla paper; oil and rag paper; oil and silicon-steel and core-plate enamel; oil and silicon steel; oil, silicon steel and core plate enamel and untreated manilla paper; oil, silicon steel and untreated manilla paper; oil, oxygen-free copper, synthetic varnish on kraft paper; and oil and black-treated tape. Prepared samples were aged at 105° and 120° C. After an ageing period of one year, the samples were allowed to cool to room temperature. Power factor measurements at 60 cycles were made on the oil of each type of sample at room temperature and at 100°C. Tensile strength tests were made on the paper strips. The papers appeared to absorb some of the high-power-factor material from the oil. The oil then remained with a low power factor and the power factor of the paper was greatly increased. The paper was found to be very brittle. The kraft and rag papers resisted heating much better than manilla paper. It would appear that the presence of varnishes or enamels affect the oil adversely. In the case of the steel and core-plate enamel, sediment, gas, and discoloration were produced. This also occurred with the phenol-alkyd varnish, which was represented as being oilproof and a satisfactory varnish for transformer impregnation. Tables are included giving the results of tests of all samples.—*F. J. Vogel, C. C. Petersen, and L. W. Matsch, Electrical Engineering.* 1951. Vol. 70, No. 3, p. 244; 4 pp.; 12 tt.

Heat Pumps in Domestic Use

Experiments made with five heat pump installations in domestic buildings in different parts of the United States have shown the complete practicability of using this method for heating and cooling. The heat pumps in question used outdoor air both both as source and sink, and air to supply heating and cooling to the conditioned spaces. The cubic volume varied from 11,500 to 20,170 cu. ft., the power required being supplied by 2 h.p. and 3 h.p. motors working in conjunction. The annual kilowatt-hours for heating and cooling were found to be some 20 to 30 per cent. greater than expected on the basis of calculated performance; no satisfactory explanation has yet been found. Changes are to be made in an endeavour to improve performance. The storage type of conditioning system may be found to be more practical when using air as source and sink. — *E. R. Ambrose, Mechanical Engineering.* 1951. Vol. 73, No. 2, p. 115; 6 ff.; 5 tt

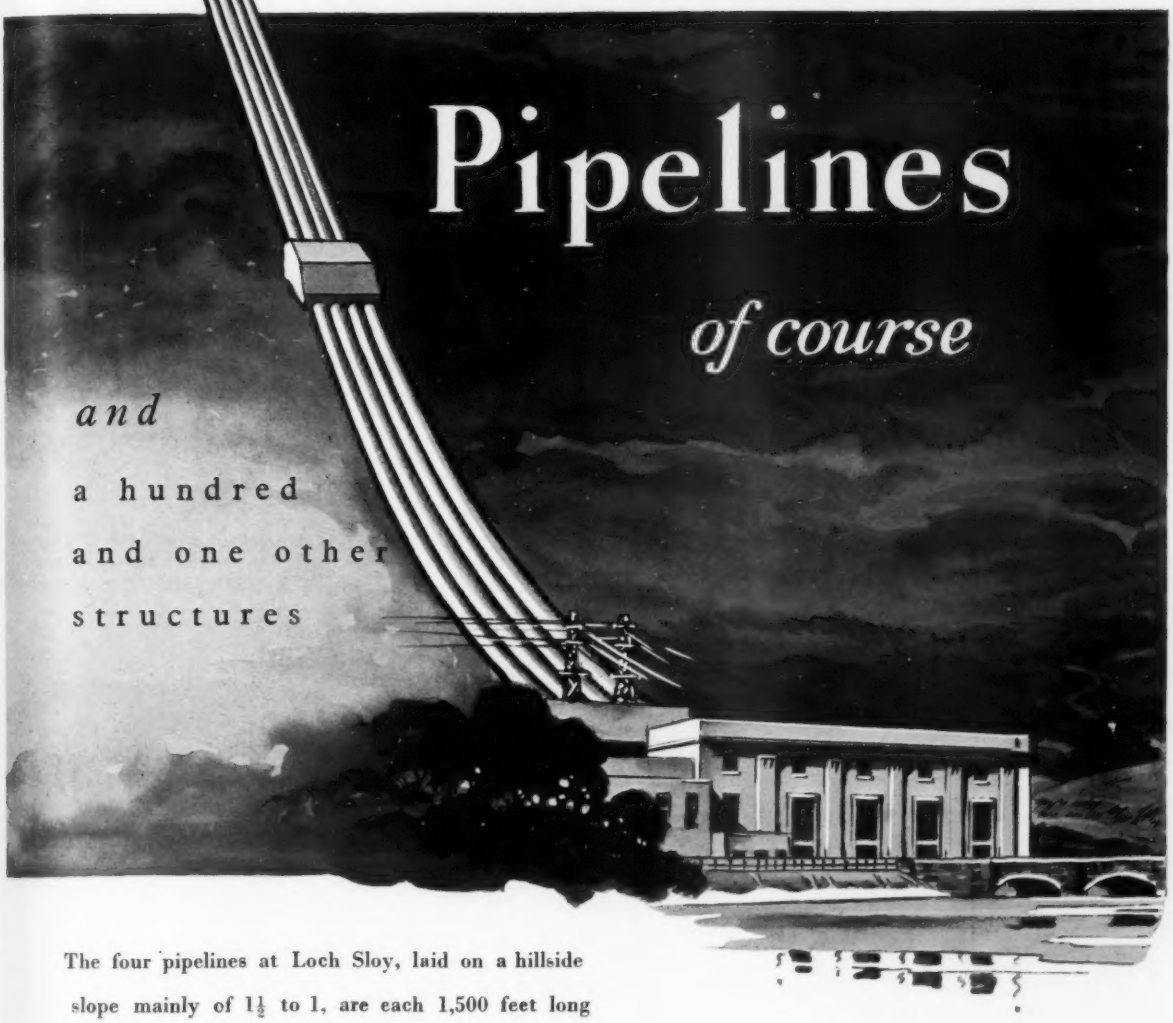
Overhead Ropeway Lubrication

The unit, operated at the Hornet mine of the Mountain Copper Co. Ltd., resembles a reagent feeder used in flotation plants. It consists of an oil-storage tank, revolving circular steel disc, hinged oil-feed chute, and a leather scraper to remove oil from the section of the disc not in contact with the tip of the feed chute. The disc is driven by the traction-cable guide pulley through a single V-belt. The quantity of oil which flows to the rope is regulated by adjusting a small lever or finger at the intake end of the feed chute. Surplus oil returns to the tank through an auxiliary channel. Flow of oil to the cable is stopped by tipping the feed chute to the non-lubricating position. — *Engineering and Mining Journal;* Vol. 152, No. 4, p. 128; 1 p.; 1 f.

Saw for Cutting Concrete

The Clipper Manufacturing Company of Kansas City, Missouri, have developed a saw to cut any concrete or asphalt flooring. Straight, smooth cuts are made with speed and ease, and provide finished edges suitable for concrete pouring. This firm have developed a complete selection of metal-bonded diamond blades for sawing concrete with limestone, flint or granite aggregate.—*Blast Furnace and Steel Plant.* Vol. 39, No. 1, p. 124; 1 p.

Arrol:



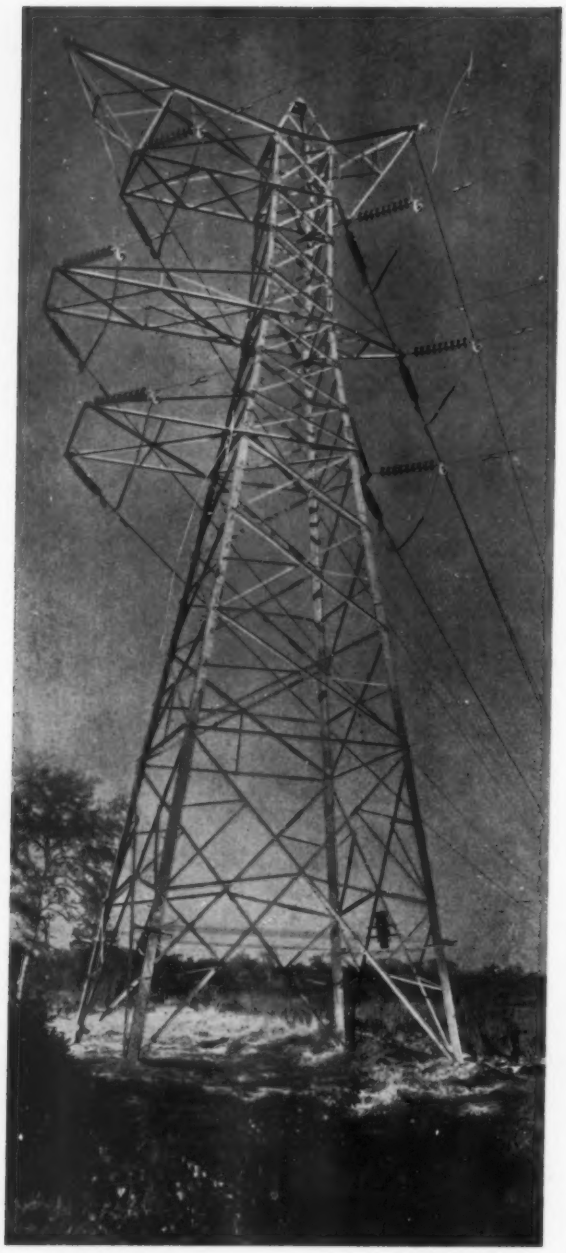
The four pipelines at Loch Sloy, laid on a hillside slope mainly of 1½ to 1, are each 1,500 feet long and of 7 feet diameter. They comprise 3,590 tons of steel. Other pipeline and penstock contracts for schemes in Portugal, New Zealand and Eire give further emphasis to the importance of the Arrol contribution to the world's water power projects.

Consulting Engineers: Messrs. James Williamson & Partners, Glasgow.

Design, manufacture and erection of all types of steel framed buildings, fixed and opening bridges, cranes and mechanical engineering work, dock gates, sliding and floating caissons, compressed air locks, hydraulic machinery, spiral casings, surge tanks, sluices and other equipment for hydro-electric stations.

SIR WILLIAM ARROL & CO. LTD., GLASGOW

Hopwood



TRANSMISSION TOWERS

Specialists in the design, manufacture and supply of towers for this country and overseas.

The complete manufacture, including galvanizing, is undertaken in these works.

"Tees Side"

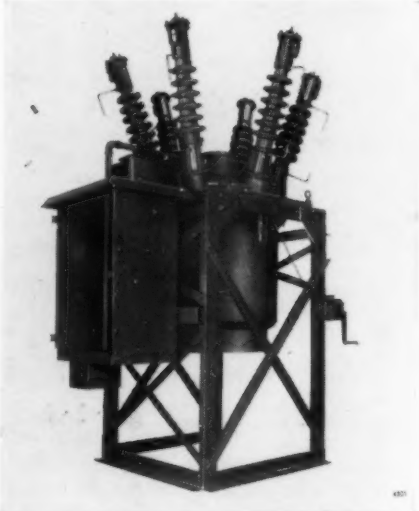
THE TEES SIDE BRIDGE & ENGINEERING WORKS LTD.
WORKS & HEAD OFFICE: MIDDLESBROUGH. TELEPHONE: 2021-4
LONDON OFFICE: 17 VICTORIA ST., S.W.1. TELEPHONE: ABBEY 1613

Far from the madding crowd

Site conditions of water power installations do not favour a tranquil life, but where the power distribution is controlled by Ferguson Pailin Switchgear there is at least one less cause for anxiety.

As specialists in the design and manufacture of switchgear, of switchgear only, and of a full range of switchgear, we are unusually well qualified to undertake complete schemes of SUPREME RELIABILITY.

Type ROP 54 oil circuit breaker for outdoor service up to 66kV.



FERGUSON PAILIN LTD

Switchgear Specialists

MANCHESTER 11, ENGLAND

Member of the A.E.I. Group of Companies

FP8.

OVERHEAD HAND POWER CRANES

EXPERTS IN VAUGHAN CRANECRAFT

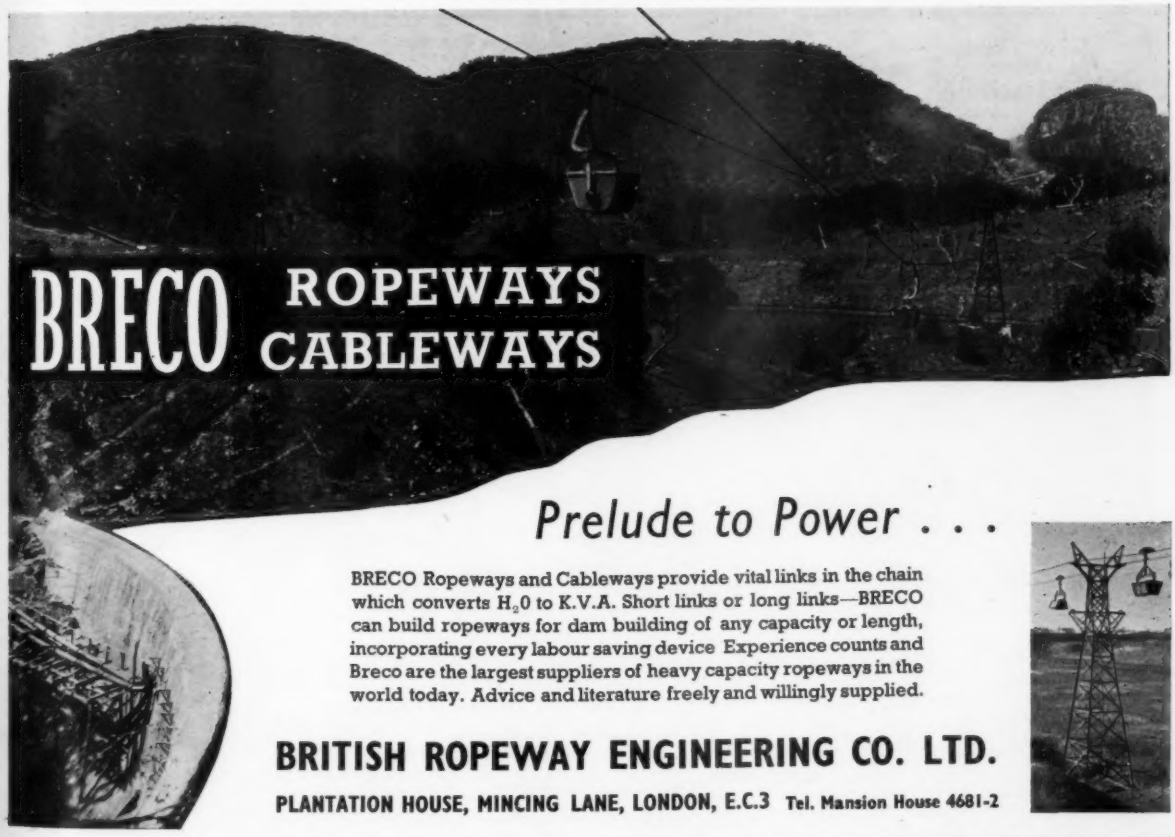
When handling loads by man-power you cannot do better than instal a VAUGHAN Hand Crane. Easy to operate, and inexpensive to maintain, these hard-wearing rugged products still find unlimited uses in modern industry

Ask for Cat. Section S.G.7. or D.G.5.

Made in Single- or Double-Girder Types and in sizes from ½ - 30 tons capacity. Roller bearing runners, high factor of safety, worm geared hoisting motion

THE VAUGHAN CRANE CO. LTD.
WEST GORTON, MANCHESTER 12.
ENGLAND.

Telephone EASt 1473.



BRECO ROPEWAYS CABLEWAYS

Prelude to Power . . .

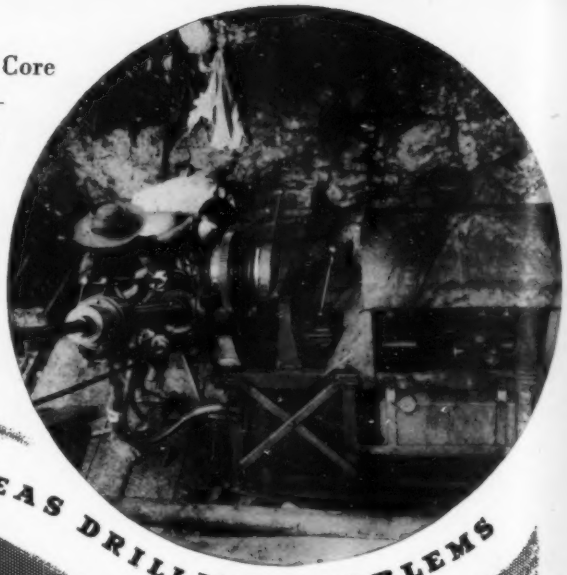
BRECO Ropeways and Cableways provide vital links in the chain which converts H_2O to K.V.A. Short links or long links—BRECO can build ropeways for dam building of any capacity or length, incorporating every labour saving device Experience counts and Breco are the largest suppliers of heavy capacity ropeways in the world today. Advice and literature freely and willingly supplied.

BRITISH ROPEWAY ENGINEERING CO. LTD.

PLANTATION HOUSE, MINCING LANE, LONDON, E.C.3 Tel. Mansion House 4681-2

ADSCO

For Water Well Drilling—Diamond Core Drilling — Geophysical Surveys, Soil Mechanics—Shaft Sinking—Adit Driving—in any part of the world.



Experience—records and technical qualifications

THE ANSWER TO YOUR OVERSEAS DRILLING PROBLEMS

ASSOCIATED DRILLING AND SUPPLY CO. (OVERSEAS) LTD.

ADSCO

Iddesleigh House, Caxton Street, Westminster, London, S.W.1. Cables: Adrillco, London Telephone: Abbey 3242 (3 lines)
P542

IT IS FUSARC-PLANNED EQUIPMENT which makes mechanised welding so productive . . .

PIPE LINES are only one example of a production welding job *planned* by Fusarc. There are scores of other examples in a wide field of work, illustrated in Fusarc Production News Sheets, free copies of which will be sent regularly on request.

FUSARC
MECHANISED WELDING

FUSARC LTD., DEPT. C841, TEAM VALLEY, GATESHEAD-ON-TYNE 11

THE RAILWAY GAZETTE
A journal of Railway Management, Engineering, Operation and Railway News.
Prepaid Annual Subscription £4 10s. 0d. *Weekly* 2s.

DIESEL RAILWAY TRACTION
A monthly review of world-wide developments in diesel-engine design and diesel railway traction operation.
Prepaid Annual Subscription 30s. *Monthly* 2s. 6d.

SHIPBUILDING AND SHIPPING RECORD
A journal of Shipbuilding, Marine Engineering, Docks, Harbours and Shipping.
Prepaid Annual Subscription £4 10s. 0d. *Weekly* 2s.

POWER AND WORKS ENGINEERING
A practical journal for Plant Owners, Engineers, and Works Managers. *Prepaid Annual Subscription* 35s. *Monthly* 2s. 6d.

NEW COMMONWEALTH
(Incorporating *The Crown Colonist*) describes and illustrates significant developments in production, trade, transportation and related spheres in all countries of the Commonwealth, and provides a unique service of economic information from 50 countries with a total population of 560 millions.
Prepaid Annual Subscription 50s. *Fortnightly* 2s.

COLLIERY ENGINEERING
A practical journal for Colliery Managers and Engineers, and manufacturers of Colliery Equipment.
Prepaid Annual Subscription 35s. *Monthly* 2s. 6d.

COKE AND GAS
A technical journal dealing with the scientific and technical problems involved in the production of coke and gas in coke ovens and gasworks, and the industrial uses of these fuels.
Prepaid Annual Subscription 30s. *Monthly* 2s. 6d.

THE INDUSTRIAL CHEMIST
A journal devoted to the progress of applied Chemistry and Engineering. *Prepaid Annual Subscription* 35s. *Monthly* 2s. 6d.

BUILDING
A practical journal devoted to Architecture and Building Practice.
Prepaid Annual Subscription 35s. *Monthly* 2s. 6d.

WOOD
A practical journal, authoritatively written, superbly illustrated, dealing with the growth, marketing and use of wood in all its forms.
Prepaid Annual Subscription 35s. *Monthly* 2s. 6d.

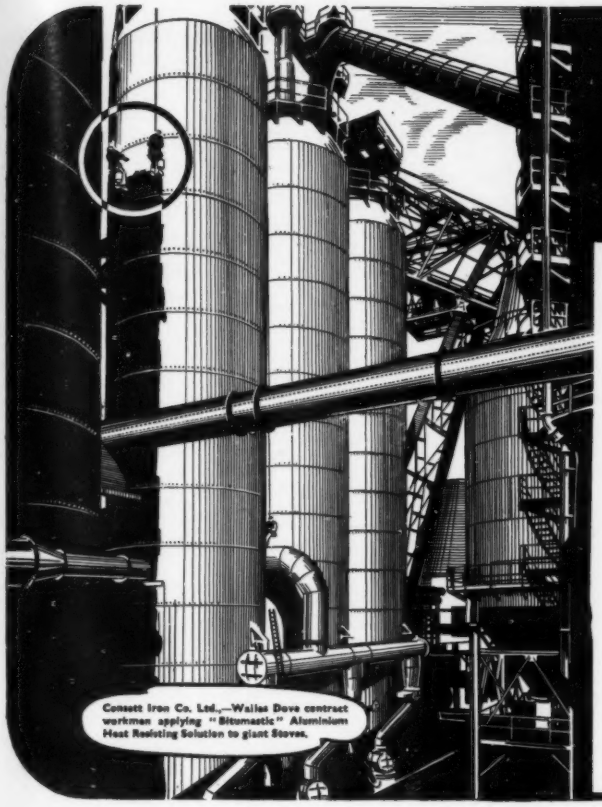
FOOD
A journal devoted to the manufacture, packing and marketing of processed foodstuffs, and of the utmost value to firms supplying equipment or materials for the food industry.
Prepaid Annual Subscription 35s. *Monthly* 2s. 6d.

WATER POWER
A technical journal devoted to the study of all aspects of Hydro-Electric Development.
Prepaid Annual Subscription 35s. *Monthly* 2s. 6d.

THE RAILWAY MAGAZINE
A popular magazine containing illustrated articles on Railways and Locomotives. Published monthly.
Prepaid Annual Subscription 26s. *Monthly* 2s.

All above published at

33, Tothill Street, Westminster, London, S.W.1


Consett Iron Co. Ltd.—Wailes Dove contract workmen applying "Bitumastic" Aluminium Heat Resisting Solution to giant Stoves.

"BITUMASTIC"
REGISTERED TRADE MARK

Contract Painting

We pride ourselves in the fact that Wailes Dove products are the finest coatings of their kind in the World We like to feel however, that our job does not end with the manufacture and sale of these materials. No matter how good a coating is, maximum protection can only be attained when the material is correctly applied. Our Contract Department will undertake the entire responsibility, furnishing skilled labour and all necessary equipment and it will ensure the very best results. May we quote you for both the supply and application of "Bitumastic" Coatings ?

WAILES DOVE BITUMASTIC LTD.,
HEBBURN • CO. DURHAM.

ANACOS
REGD.

OVERHEAD LINES

in

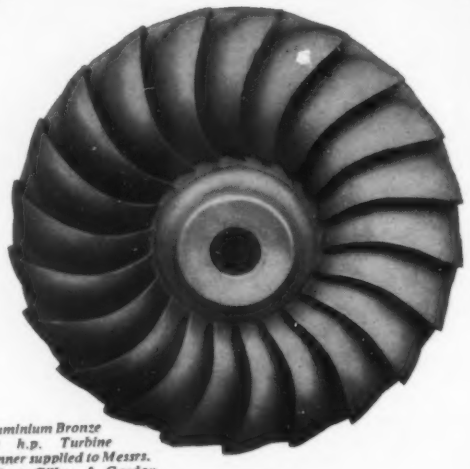
Hard drawn Copper, Cadmium-Copper and Steel cored Aluminium to relevant British Standards.

We are pleased to quote to your specification.

FS & CO

INCORPORATED IN THE LONDON ELECTRIC WIRE COMPANY AND SMITHS LIMITED

FREDERICK SMITH & COMPANY
ANACONDA WORKS : SALFORD 3 : LANCS.
Incorporated in The London Electric Wire Company and Smiths, Limited
Associated with The Liverpool Electric Cable Co., Ltd. and Vactite Wire Co., Ltd.



Aluminium Bronze 180 h.p. Turbine Runner supplied to Messrs. Gilbert Gilkes & Gordon Ltd., of Kendal, England

BIRSO TRADE MARK

HIGH TENSILE
ALUMINIUM BRONZE
CASTINGS
for
WATER POWER
INSTALLATIONS

possess a Tensile Strength of 45 tons per sq. in., have a specific gravity of only 7.5 and are guaranteed to withstand any hydraulic pressure; also highly resistant to erosion, corrosion and abrasion.

We are specialists in all kinds of Non-Ferrous Castings — in PHOSPHOR BRONZE, GUN-METAL, MANGANESE BRONZE, ETC. and in Light Alloy Castings, Chill-Cast Phosphor Bronze Rods and Tubes, Precision Machined Parts, etc.

Fully approved by Admiralty and A.I.D.

B104

T. M. BIRKETT & SONS. LTD.
HANLEY · STAFFS
'Grams: Birkett, Hanley 'Phone: Stoke-on-Trent 2184-5-6
in association with
BILLINGTON & NEWTON LTD.
LONGPORT, STOKE-ON-TRENT
'Grams: Bronze, Phone, Longport 'Phone: Stoke-on-Trent 87303-4 & 88147

HYDRO ELECTRIC EQUIPMENT

- HYDRAULIC TURBINES
- BUTTERFLY VALVES
- AIR VALVES
- AIR LOCKS
- PENSTOCKS AND SIPHONS
- SURGE TANKS
- HEAD GATES AND SLUICE GATES
- RADIAL GATES
- STOP LOG HOISTS
- TRASH RACKS AND RAKES
- GANTRY CRANES

HEAD GATES

CANADIAN VICKERS MONTREAL LIMITED
CANADA
Cable Address: VICKERS, MONTREAL.
V-221

Specify MICHELL BEARINGS
AND MAKE SURE OF YOUR

THEY 'SET THE COURSE' FOR ENDURING RELIABILITY

for Hydro Electrical Installations, Turbine Thrusts, Pedestal Bearings, Motors, Generators, Pumps (Vertical and Horizontal), Fans, Paper-Making and Extruding Machines, etc.

MICHELL BEARINGS

SOUTH BENWELL NEWCASTLE upon TYNE

Telegrams: MICHBEARO
Telephone: 34279

OUTDOOR SWITCHGEAR

IVIO

Performance is proved by years of testing in our Climatic Laboratory and confirmed by numerous installations in the most severe tropical areas.

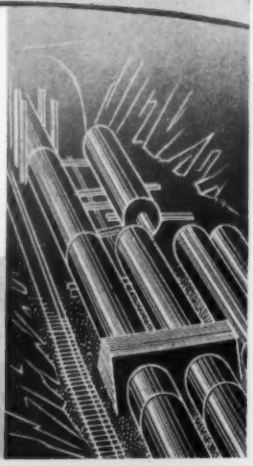
Saving in cost and time of buildings is an additional factor in the increasing popularity of IVIO Outdoor Switchgear.

The equipment illustrated on left was supplied to the Eastern Electricity Board, North Met. Sub. Area, Bishop's Stortford, Herts.

YORKSHIRE SWITCHGEAR & ENGINEERING CO. LTD. LEEDS and LONDON

ASSOCIATED WITH ELECTRO MECHANICAL MANFG. CO. LTD. · SCARBOROUGH

PIPE LINE WINCH



HYDRO-ELECTRIFICATION SCHEME, MOYAR

75 h.p. Motor . . . 7 ft. dia. Drum . . . 1⅜in. dia. Rope
150 f.p.m. Rope Speed . . . 41½ degrees Maximum Gradient . . . Load 6 tons Hoisting, 18 tons Lowering
Road 2,200 ft. Long
Pull in Rope Maximum 30,000 lbs.

M. B. WILD & CO LTD NECHELLS BIRMINGHAM 7

Telephone: EAST 2041-7 Telegrams & Cables: HOISTING BIRMINGHAM 7

INDEX TO ADVERTISEMENTS

A
Allgemeine Elektricitats Gesellschaft 35
Allmanna Svenska Electriska Aktiebolaget 21
Anderson-Grice Co. Ltd. 50
Armfield Hydraulic Engineering Co. Ltd., The ... ... —
Arrol, Sir. Wm. & Co. Ltd. 43
Associated Drilling & Supply Co. (Overseas) Ltd. 46
Ateliers de Constructions Electriques de Charleroi 9
Ateliers de Constructions Méchaniques de Vevey S.A. 19
Atlas Diesel Co. Ltd. ... 26 & 27

B
Balfour, Beatty & Co. Ltd. ... ... —
Bell, Theodore, Ltd. ... ... —
Billington & Newton Ltd. 48
Birkett, T. M. & Sons Ltd. 48
Blackwood, Hodge J. & Co. Ltd. ... 24
Blakeborough, J. & Sons Ltd. ... —
Blaw Knox Ltd. 8
Boving & Co. Ltd. ... *Front Cover*
Brady, G. & Co. Ltd. 20
British Insulated Callenders Cables Ltd. 42
British Pitometer, The, Co. Ltd. ... 38
British Ropeway Engineering Co. Ltd. 45
British Thomson-Houston Co. Ltd. 36
Brown Boveri & Co. Ltd. 5
Bruce Peebles & Co. Ltd. 6
Butters Bros. & Co. Ltd. 13

C
Canadian Vickers Limited 48
Cementation Co. Ltd., The 32
Ceretti & Tanfani Ropeway Co. Ltd. 29
Christiani & Nielsen 22
Climax Rock Drill & Engineering Works Ltd. 15
Consolidated Pneumatic Tool Co. Ltd. 12
Costain, Richard, Ltd. 34
Crompton Parkinson Ltd. ... ... —

D
Dominion Engineering Co. Ltd. ... 4

E
English Electric Co. Ltd. 3
Escher Wyss Ltd. 7

F
Fabbriche Riunite Cemento ... 14
Ferguson Pailin Ltd. 44
Fusarc Ltd. 46

G
General Electric Co. Ltd. 28
Gilbert Gilkes & Gordon Ltd. ... 11
Glenfield & Kennedy Ltd. ... ... —

H
Hackbridge & Hewittic Electric Co. Ltd. ... ... —
Harland Engineering Co. Ltd., The 40
Henderson, John M. & Co. Ltd. ... 18
W. T. Henley's Telegraph Works Co. Ltd. 10
Holman Bros. Ltd. ... *Inside Back Cover*

K
Karlstads Mekaniska Werkstad ... —

L
Leffel, James & Company, The ... —

M
Maschinenfabrik Augsburg-Nuernberg A.G. ... ... —
Mechans Ltd. ... ... —
Metropolitan-Vickers Electrical Co. Ltd. ... ... *Back Cover*
Michell Bearings 48
Millars Machinery Co. Ltd. ... —
Morris, Herbert Ltd. 39

N
Newport News Shipbuilding & Dry Dock Co. 31
North of Scotland Hydro-Electric Board ... ... —
Nuttall Edmund Sons & Co. (London) Ltd. 37
Nydqvist & Holm Akt. ... ... —

O
Oerlikon Engineering Company ... —

P
Pirelli-General Cable Works Ltd. ... 25

R
Ransomes & Rapier Ltd. ... ... —
Rawlplug Co. Ltd., The ... ... —
Reyrolle, A. & Co. Ltd. *Inside Front Cover*

S
Scarpa & Magnano 38
Smith, Fredk. & Co. 47
Smith, Thos. & Sons (Rodley) Ltd. —
South Durham Steel & Iron Co. Ltd. —
Standard Telephones & Cables Ltd. 23
Steatite & Porcelain Products Ltd. ... 30

T
Taylor, Tunnicliff & Co. Ltd. ... —
Teeside Bridge & Engineering Works Ltd., The 44

V
Vaughan Crane Co. Ltd. 45
Voith, J. M., G.m.b.H. 33

W
Wailes Dove Bitumastic Ltd. ... 47
Watson, Robert & Co. (Constructional Engineers) Ltd. ... ... —
Westinghouse Electric International Company ... ... —
Wild, M. B. & Co. Ltd. 49
Wood, Hugh & Co. Ltd. 17

Y
Yorkshire Electric Transformer Co. Ltd. 16
Yorkshire Switchgear & Engineering Co. Ltd. 49

ANDERSON DERRICK CRANES

5-ton Electric Derrick Crane x 130 ft. Jib.

Outstanding Design Features :

- **PROGRESSIVE DESIGN TO B.S.S. 327/1**
- **EXCLUSIVE "UNIT" GEARING**
- **SUPERIOR VISIBILITY**
- **HIGH SPEED OPERATION**
- **RELIABILITY & ECONOMY**
- **INTERCHANGEABLE SPARES**

LONDON OFFICE:
Finsbury Pavement House
120 Moorgate, E.C.2
Telephone: MONarch 4629

Phone: Carnoustie 2214-5

THE ANDERSON-GRICE CO. LTD.
TAYMOUTH ENGINEERING WORKS - CARNOUSTIE - SCOTLAND

Grams: DIAMOND, CARNOUSTIE

LONDON: Published by TOTHILL PRESS LIMITED, Proprietors of WATER POWER, at 33 Tothill Street, Westminster, S.W.1, and Printed by W. & H. SMITH LTD., Evesham, Worcestershire. *November, 1951.*

1801 Holman 1951
150 YEARS

ANY ROCK DRILLING QUESTION HAS A HOLMAN ANSWER

HANDRILS. The Silver Bullet (illustrated), S.L.200, Silver Dart, S.L.9D., and Silver Eight give excellent results with the Airleg. The full range includes drills for all purposes. Weights from 22 to 84 lb.

"S.L." SINKERS. Ideal for any deep-hole work. Weights 106, 111 and 120 lb.

STOPERS. Telescopic air-feed machines. Available with automatic rotation. Weights 90, 93 and 120 lb.

HOLBITS. Tungsten Carbide Tipped Bit. Cross and Chisel Types in various sizes from 1 1/8 in. to 2 in., and in two grades of tungsten carbide.

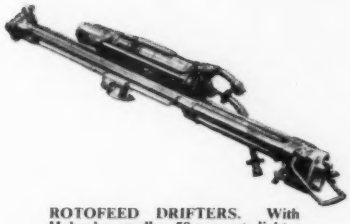
Since the first Holman Rock Drill was patented in 1881, there have appeared countless variations and developments of the original machines. Today there is Holman Rock Drill Equipment suitable for every type of mining, quarrying and constructional engineering—in any formation. And at Camborne new designs and modifications are constantly being produced and tested in the never-ceasing quest for even more efficient, economical and labour-saving equipment.

From the smallest of the familiar Handrils to the latest Hydraulic Drilrig, *every* machine is precision-made and inspected, component by component, and exhaustively tested in the Holman Experimental Mine for speed and air consumption.

Detailed and illustrated literature on all these machines will be promptly supplied on request. Are you on our mailing list?

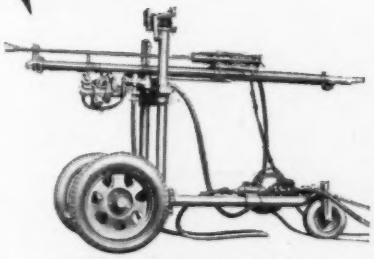
BROS. LTD.
Holman
CAMBORNE . ENGLAND

AIRLEG. Provides constant feed pressure while supporting the weight of the Handril. Enables holes to be drilled in any direction, and can be operated with nearly every Handril in the range.



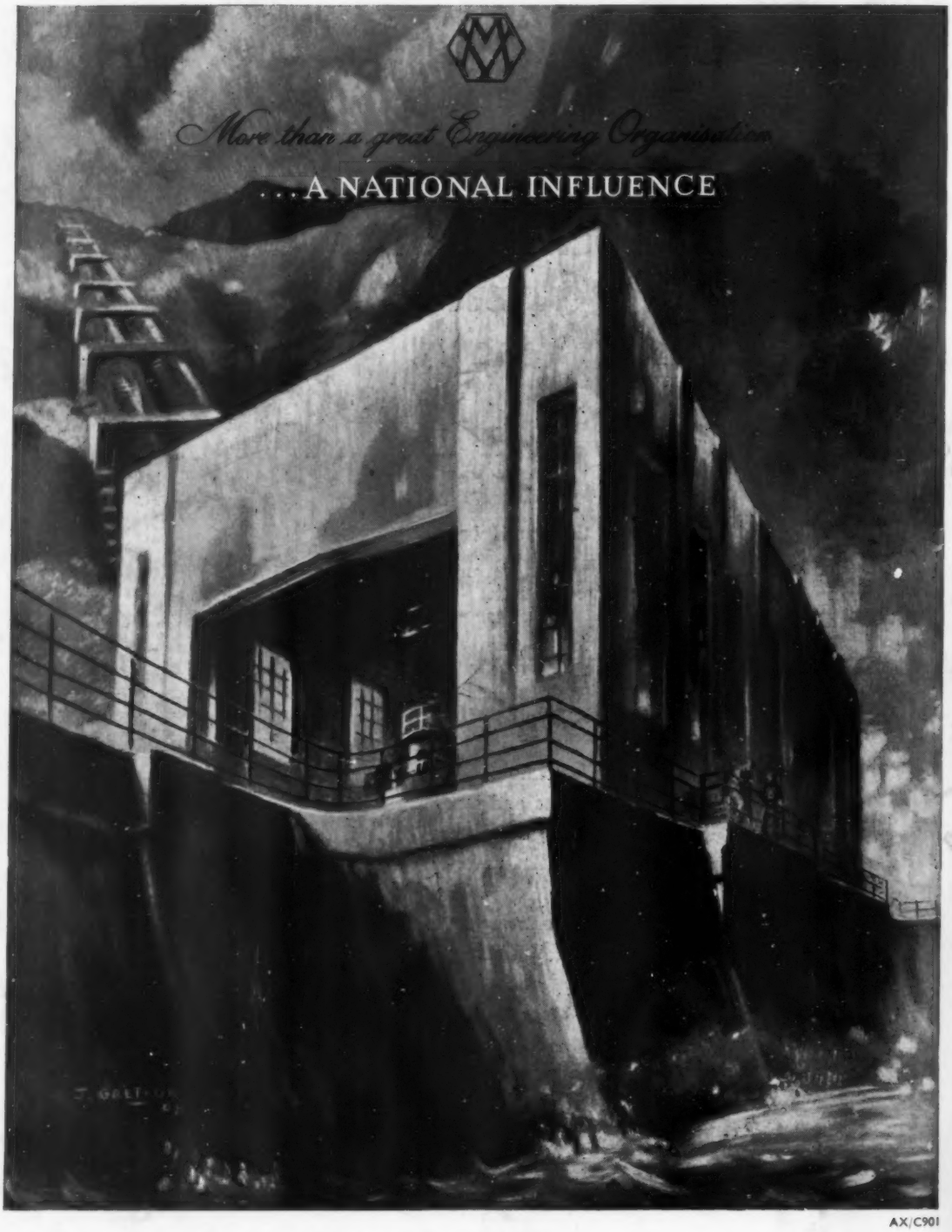
ROTOFEED DRIFTERS. With Holmaloy cradle—50 per cent. lighter than steel types. Constant penetration speed with rapid retraction. Weights from 114 to 180 lb.

DRYDUCTOR. Drill for Dust-free dry rock drilling. Traps dust at source and removes it from the face. Hand-held or on any mounting, will drill at any angle.



WAGON DRILL. Mounted on a wheeled tripod (steel or pneumatic tyres)—gives a feed length of 84 in., and can be rigged for drilling from the vertical downward position to 20° above horizontal.

PHONE: CAMBORNE 2275 (9 LINES) GRAMS: AIRDRILL, CAMBORNE
SUBSIDIARY COMPANIES, BRANCHES AND AGENCIES THROUGHOUT THE WORLD HB4



AX/C901

HYDRO-ELECTRIC GENERATING PLANT

Water turbine driven Generators, Transformers, Rectifiers, H.V. & L.V. Switchgear, Instruments, Meters and Relays, Motors and Control Gear, Synchronous Condensers, Supervisory and Automatic Control Equipment, Voltage Regulators, Isolators, Lightning Arrestors, Feeder Protective Gear, etc.

"Covering every side of the Electrical Industry."

METROPOLITAN - VICKERS ELECTRICAL CO., LTD., MANCHESTER, 17, ENGLAND

Member of the A.E.I. group of companies